The Application of High Intensity Flotation Technology at Mt Keith Nickel Concentrator

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ABSTRACT

Conventional flotation technology has historically failed to achieve high recoveries when treating <15 μm particles (Lynch et al, 1981). The new StackCell™ flotation technology was developed to specifically target this particle size range, and was tested at pilot plant scale at Mt Keith Nickel Concentrator. The streams tested, Slimes Rougher Tailings and Fines/Slimes Cleaner Tailings, represent 21% and 11% of the total nickel lost to tailings in the plant. Laboratory scale test work indicated that an economically significant fraction of these losses was consistently available to be recovered by additional flotation.

The pilot plant experimental scope included over 50 tests. A grade recovery curve for each stream was developed, as well as information on the effect of ore type, feed rate, wash water, air flow, collector and frother on the performance of the cell.

The single StackCell was able to achieve nickel recoveries of 16.8% and 16.5% on the Rougher Tailings and Cleaner Tailings, respectively, at grades consistent with these blocks. Additional test work of the StackCell in a cleaner scalper duty yielded final quality concentrate with a maximum nickel recovery of 59.5% for the single stage StackCell. Laboratory scale simulation of the downstream impacts of the StackCell operating as a cleaner scalper indicated a net recovery benefit of up to 2.0% for this cleaner block.

Tests were completed to compare residence time requirements of the StackCell, as compared to conventional flotation. In 55 seconds, the pilot plant StackCell achieved 50% of the recovery of a 960 second laboratory scale conventional flotation on the same feed material. The apparent improvement in flotation kinetics is attributed to the novel high intensity aeration system, which provides efficient bubble-particle contact thereby shortening the residence time required to achieve high recoveries.

The smaller footprint and lower energy costs of such a cell are also benefits of this technology, which is being considered for industrial scale installation as a result of this test work. Given the industry's historical poor performance treating slimes with conventional flotation, it is clearly best practice to challenge the status quo through innovative new technology, such as the StackCell.

INTRODUCTION

Mt Keith nickel concentrator

The Nickel West Mount Keith Operation (NMK) consists of a large, low grade disseminated nickel sulfide orebody treated by crushing and two staged closed circuit grinding (SAG & Ball Mills), followed by a complex split-size rougher, scavenger and cleaner flotation circuit (Figure 2).

The Mount Keith orebody was first discovered in 1968, however it took until 1989 before technological advances made development of the concentrator economically viable. The concentrator was commissioned in 1994 as a 6.6 Mt/y operation. A debottlenecking and expansion program from 1997 through to 1999 improved annual throughput to 11.5 Mt/yr. A number of major projects were also completed to improve plant recovery, such as:

- sulfuric acid addition to the scavenger banks (1999)
- separate size flotation (2000)
- coarse scavenger concentrate regrind (2001)
- Talc Redesign Project (2012).

The Talc Redesign Project (TRP) was developed due to the increasing amount of high talc content ore forecast to be treated by the concentrator from both the existing Mount Keith deposit and from the nearby undeveloped Yakabindie deposit. To improve performance on this ore, the TRP made several changes:

- increased flotation capacity
- sequenced regrinding for further liberation of sulfides
- additional reagents to improve sulfide flotation
- minimisation of recycles to limit ability of talc to reconnect with sulfides.

Ore from the Mount Keith open pit can be broadly classified into two types: talc and non-talc. Non-talc ore is primary, unaltered ore consisting of predominantly disseminated pentlandite, pyrrhotite and pyrite in a serpentinised olivine (lizardite) matrix with significant brucite and iowaite, typically containing less than 2% talc (measured by XRD). Talc ore has been hydrothermally altered to a talc-magnesite-antigorite matrix containing disseminated pentlandite, pyrite and minor violarite, with greater than 2% talc. Talc ore can also contain high amounts of arsenic present as gersdorffite. The two ore types have significantly different optimal flotation conditions in the Mount Keith concentrator and every effort is made during mining and crushing to keep them separate.

StackCell

Eriez’s StackCell is a relatively new froth flotation technology, targeted at fines and slimes particles. It was developed in light of the engineering and design challenges that are commonly associated with existing flotation technology such as self-aspirating cells, mechanical cells and Jameson cells. These challenges include high energy consumption, large floor space requirement and size. This technology was designed specifically to overcome these challenges by providing an efficient separation, but also with respect to equipment size, energy consumption and installed costs.

StackCells have been installed at industrial scale in coal, copper and gold processing plants. There are currently no StackCells installed in Australia, or in nickel processing worldwide.

Figure 1 - StackCell Pilot Unit Schematic

Figure 1 illustrates the features of the StackCell technology. During operation, feed slurry is introduced to the cell through a side (or bottom) feed port. At this point, low pressure air is added to the feed slurry. The aerated feed slurry then travels into the aeration chamber where significant shear is imparted to the system. The shear forces imparted to the system are used to create bubbles for bubble-particle collisions. In fact, all of these bubble-particle collisions occur in the aeration chamber prior to discharge into the outer tank. Once the slurry enters the outer tank, phase separation occurs between the froth and pulp. A pulp level is maintained in the outer tank to provide a deep froth that can be washed to minimize the entrainment of non-sulfide gangue (NSG) material. The froth overflows into a froth collection launder, while the tailings are discharged using either a control valve or mechanical weir system. The system is specifically designed to have both a small footprint and a gravity-driven feed system.

Mt Keith Target Streams

Given the design intent of the StackCell, several streams in the Mt Keith circuit were identified as potentially suitable to this technology:

- Slimes Rougher Tailings
- Slimes/Fines Cleaner Tailings (aka Secondary Cleaners)
- and after these streams were tested, the Slimes/Fines Cleaner Feed (aka Secondary Cleaners)

Slimes rougher circuit

As explained, the Mt Keith circuit consists of two modules. The two slimes rougher circuits differ slightly between modules.

- Module 1 consist of a 280 m^3 column, followed by six conventional Outotec 100 m^3 cells
- Module 2 has an identical column, followed by three conventional Outotec 150 m^3 cells.

As these streams are comparable in terms of particle size, composition and flow, only one was tested, with the results considered applicable to both streams. Module 2 was selected due to ease of access. Historical daily laboratory analysis of the Module 2 Slimes Rougher Tailings (2SLIT) indicated that the average grade was 0.27% Ni. Considering the flow and solids density of this stream, this is the equivalent of 2029 Ni t/y lost.

Secondary cleaner circuit

Installed as part of the Talc Redesign Project, the Secondary Cleaner circuit consists of five conventional Outotec 70 m^3 cells. The concentrate from these cells reports to the Secondary Recleaners, a bank of five conventional Outotec 10 m^3 cells, with recleaner tailings reporting back to the head of the cleaner circuit. The Secondary Cleaner Tail reports to final tailings.

Historical daily laboratory analysis of the Secondary Cleaner Tail (SCT) indicated that the average grade was 0.43% Ni. Considering the flow and solids density of this stream, this is the equivalent of 2159 Ni t / y lost.

Experimental scope overview

Four trials were completed. The first round of test work was completed in September 2016, and included Trials 1 and 2. Later, Trials 3 and 4 were undertaken. The feed material for each trial was obtained from various locations throughout the flotation circuit as presented in Figure 2. Furthermore, Table 1 provides description and characteristics of the feed material, including head grade and particle size.

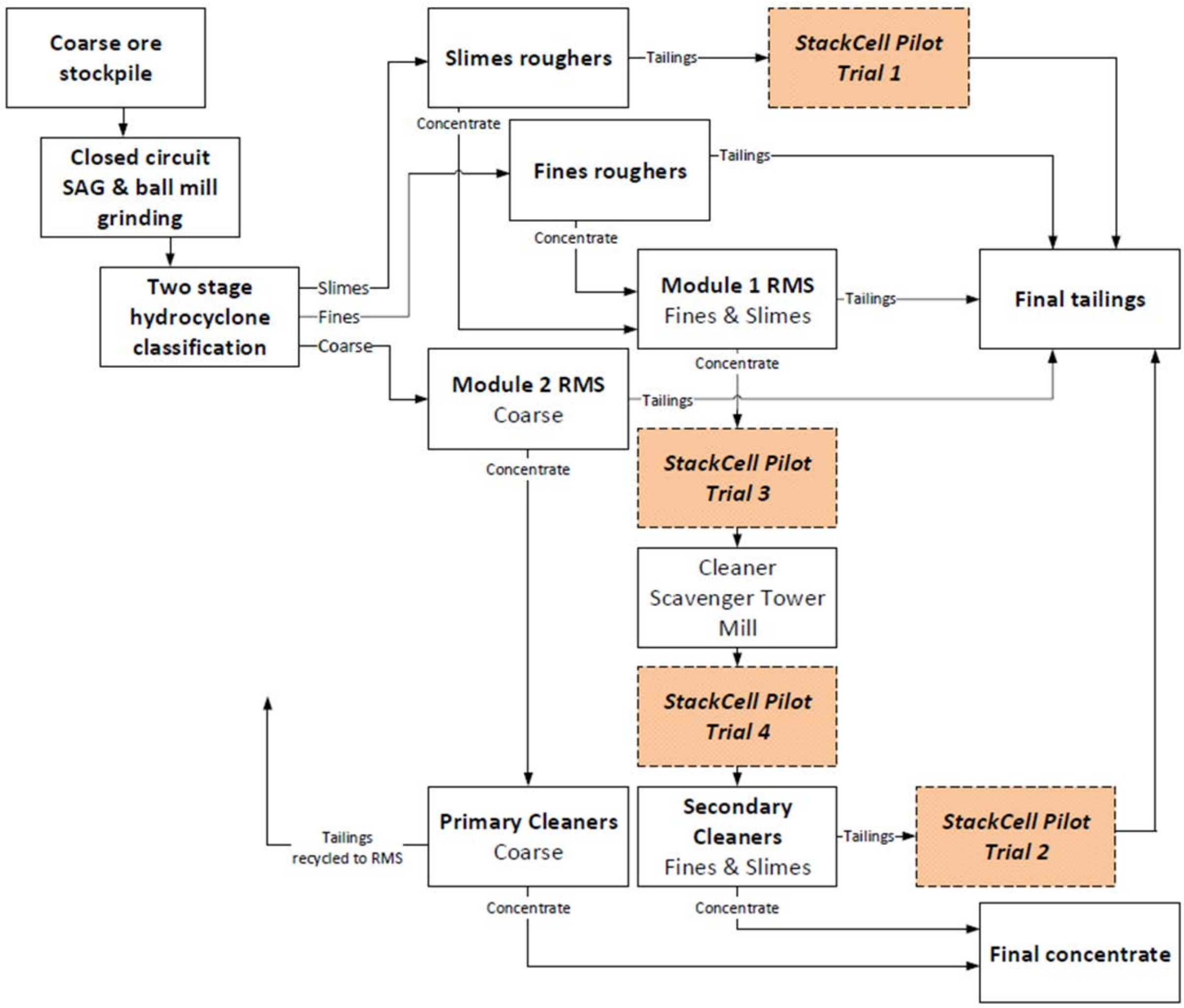

Figure 2 - Mt Keith Simplified Process Flow Diagram

Table 1 - Trial Stream Data

Trial	Stream	Typical nickel grade (% mass)	Typical particle size (P80, µm)	Typical volumetric flow (m3/h)
1	Slimes Rougher Tailings (SLIT)	0.268%	30	1,150
2	Secondary Cleaner Tailings (SCT)	0.429%	30	690
3	Cleaner Scavenger Tower Mill Feed	1.592%	40	660
4	Cleaner Scavenger Tower Mill Product	1.592%	30	660

As very little information regarding the performance of the StackCell in sulfide flotation was available, the initial goal of this test work was to prove the technology. Twenty eight tests were completed for Trial 1, with the StackCell in a Slimes Rougher Scavenger duty. An additional 30 tests were completed for Trial 2, with the StackCell in a Cleaner Tailings Scavenger duty. These tests aimed to prove the technology by collecting grade-recovery data for several operating points.

As optimum operating parameters were not known, a baseline was selected and the following parameters varied for each subsequent test:

- air flow rate
- froth depth
- slurry feed flow rate
- wash water flow rate
- collector addition
- frother addition.

In this way, a wide range of operating points were observed, yielding a grade-recovery curve for Trials 1 and 2, and also information regarding the effect of varying these parameters.

Concerns were raised about the amenability of this technology to talc ore, therefore the scope of Trial 2 was expanded to include talc ore tests. Furthermore, it was speculated that the floatability of StackCell concentrate in a conventional flotation cell may be somewhat reduced, as compared to concentrate produced via conventional flotation. Laboratory tests were therefore completed to address this concern.

The partially successful Trial 2 tests were expanded in a final round of test work in January 2016, which aimed to better quantify the performance of the StackCell while acting in a cleaner-scalper duty (Trials 3 and 4). As the Secondary Cleaner feed passes through a tower mill before reporting to the Secondary Cleaners, tests were conducted immediately upstream and downstream of this mill, to identify which (if any) location had greater performance. As the tailings of a StackCell operating in this duty would be reporting to the Secondary Cleaner feed in an industrial scale application, the downstream performance of this Secondary Cleaner block would be diminished due to the lower quality 'scalped' feed. In order to simulate the magnitude of this effect, and therefore evaluate the net impact of a StackCell operating in the middle of the process, the Secondary Cleaner Recleaner block was simulated with laboratory scale flotation tests. Both the StackCell pilot unit feed and tailings were tested on two different ore types for Trials 3 and 4, thereby simulating an on/off trial of the StackCell in this cleaner scalper duty.

EXPERIMENTAL RESULTS

A summary of the number of tests in each trial, and average StackCell parameters is shown below in Table 3.

Table 2 - Mt Keith Pilot Test Work Chronology

Date	Stream	Goals
September 2016	Slimes Rougher Tailings *(Trial 1 in Figure 2)*	Proof of technology
	Secondary Cleaner Tailings *(Trial 2 in Figure 2)*	Proof of technology
December 2016	Secondary Cleaner Tailings *(Trial 2 in Figure 2)*	Quantify performance treating talc ore
	Secondary Cleaner Feed *(First Cleaner Cell)*	Quantify performance treating this stream
January 2016	Tower Mill Feed *(Trial 3 in Figure 2)*	Quantify performance treating this stream
	Tower Mill Overflow *(Trial 4 in Figure 2)*	Quantify performance treating this stream

Table 3 – StackCell Operating Parameters

Trial	Carrying capacity t /h /m^2	Volumetric capacity m^3 /h /m^2	Contact time sec	Number of tests
1	0.17	82	55	28
2	0.05	49	93	30
3	0.19	28	170	10
4	0.20	28	169	10

Slimes rougher tailings scavenger duty

Grade recovery curve

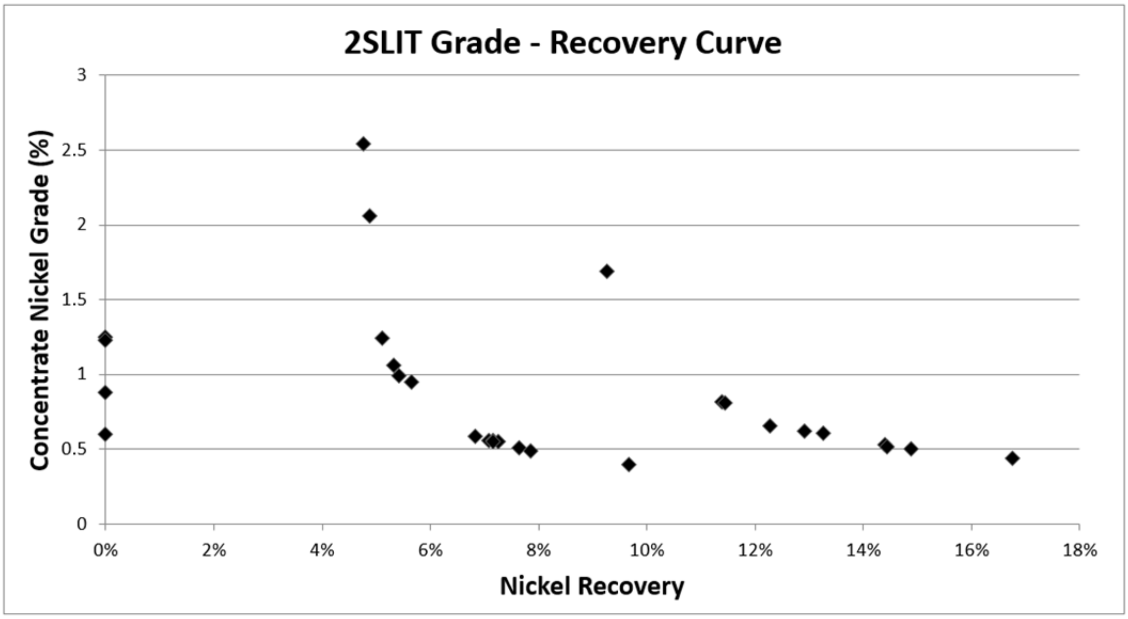

Figure 3 – Slimes Rougher Tailings Grade-Recovery Curve

Nickel recovery was calculated using a two-product formula, relying on the feed, concentrate and tail assay data.

Several test results indicated 0% recovery. Concentrate was indeed collected for these tests, with an appreciable nickel grade, therefore the actual nickel recovery was not truly zero. However, due to the detection limit for nickel through XRF analysis, the feed and tail assays were returned as the same value, therefore the recovery appears to be zero. The non-zero recovery tests are split into two distinct groups. The group of results bounded between nickel recoveries 4-10%, generally speaking, experienced a 0.01 percentage point reduction from nickel grade in feed to tail. The group of results between 10-17% experienced a 0.02% or greater reduction from nickel grade in feed to tail. There were no other parameters responsible for this separation (i.e. ore type, reagents, froth depth etc.).

Excluding the zero recovery tests, the average head grade was 0.24%, achieving an average nickel recovery of 8.9%. The average concentrate nickel grade was 0.86%, which is in line with the slimes rougher concentrate block grade. There were, however, several tests with greater recoveries and grades than these averages, which are perhaps better indications of the potential optimum operating point of this unit.

Parameter analysis

Six parameters were varied throughout the test work to observe their impact on the performance of the StackCell. The results of these tests are presented below alongside the full data set, for comparison.

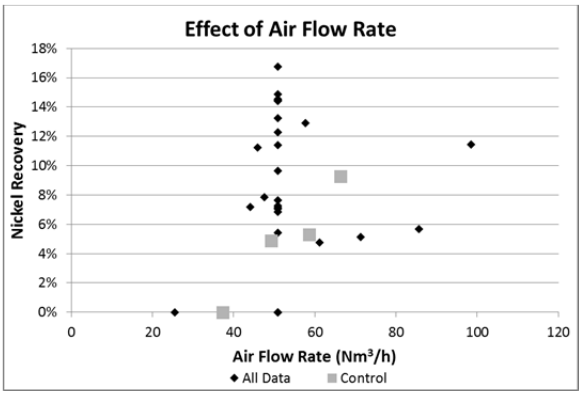

Figure 4 - Slimes tail, Recovery vs Air Flow

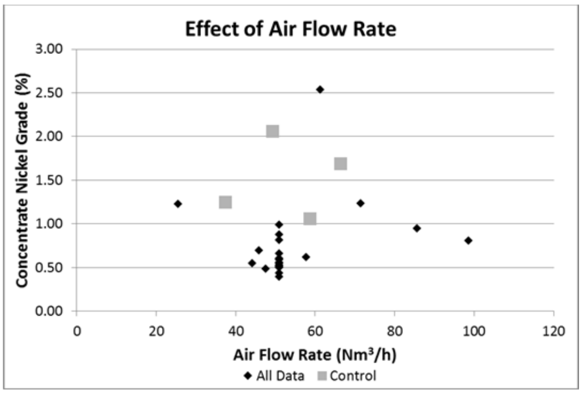

Figure 5 - Slimes Tail, Grade vs Air Flow

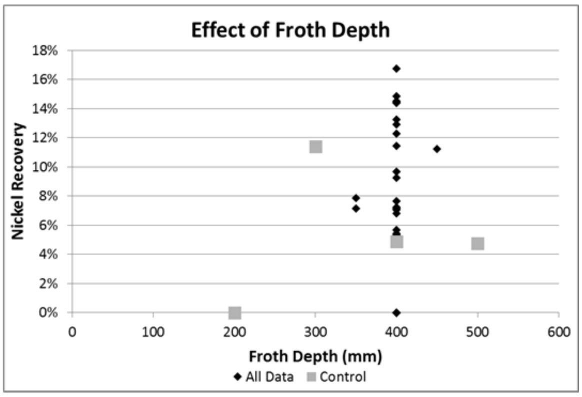

Figure 6 - Slimes Tail, Recovery vs Froth Depth

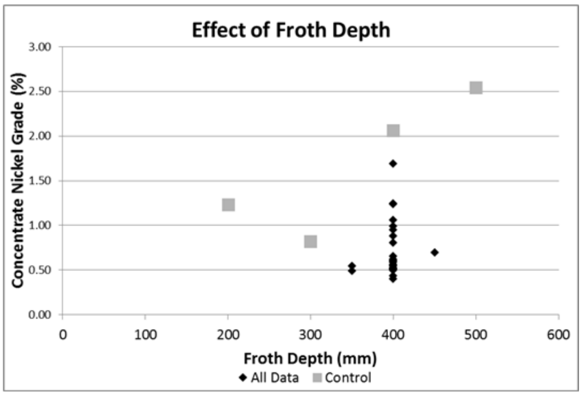

Figure 7 - Slimes Tail, Grade vs Froth Depth

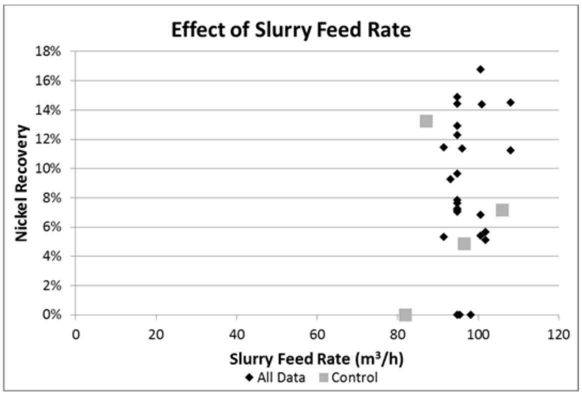

Figure 8 - Slimes Tail, Recovery vs Feed Rate

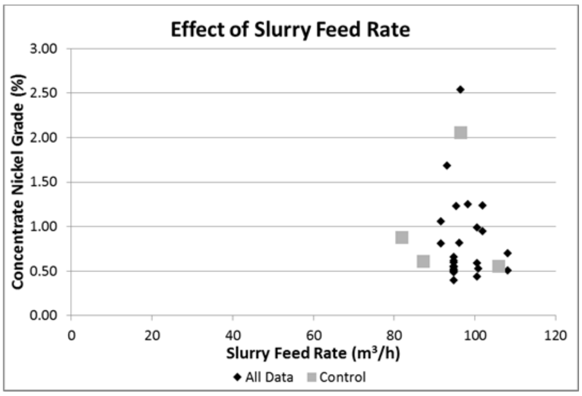

Figure 9 - Slimes Tail, Grade vs Feed Rate

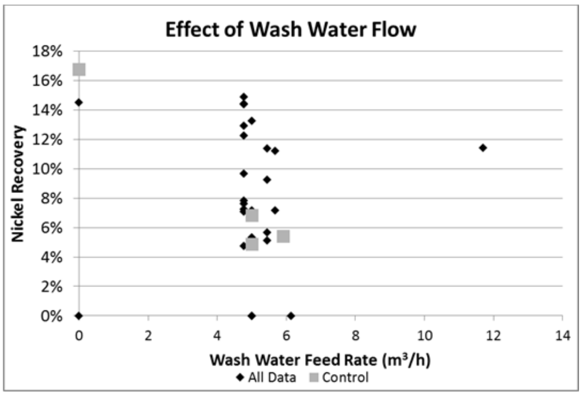

Figure 10 - Slimes Tail, Recovery vs Wash Water

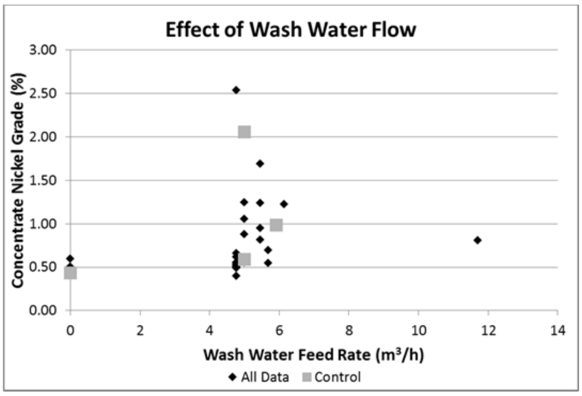

Figure 11 - Slimes Tail, Grade vs Wash Water

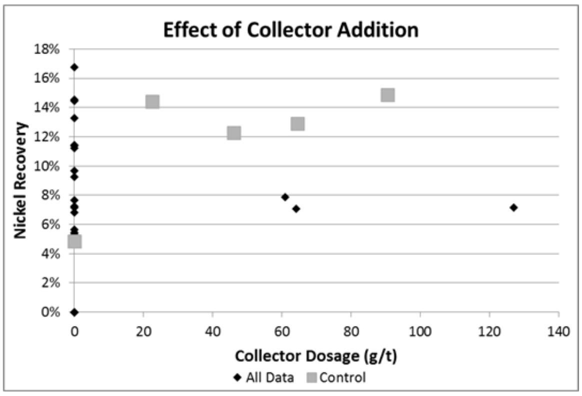

Figure 12 - Slimes Tail, Recovery vs Collector

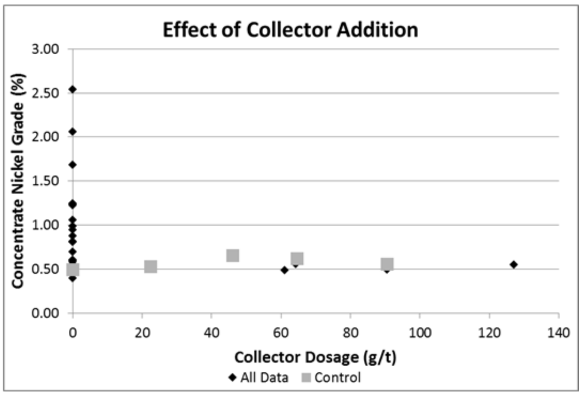

Figure 13 - Slimes Tail, Grade vs Collector

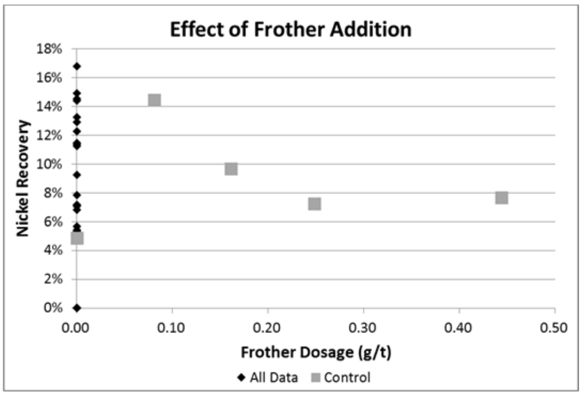

Figure 14 - Slimes Tail, Recovery vs Frother

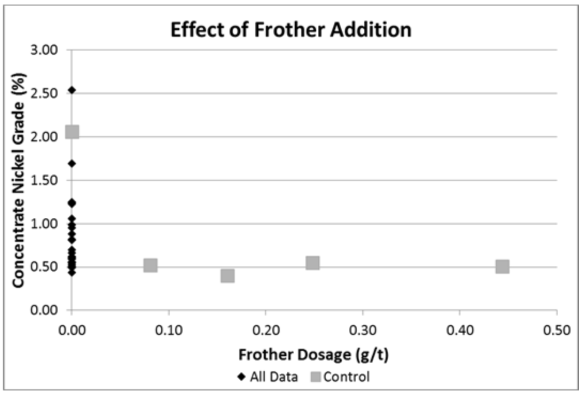

Figure 15 - Slimes Tail, Grade vs Frother

Cleaner tailings scavenger duty

Grade recovery curve

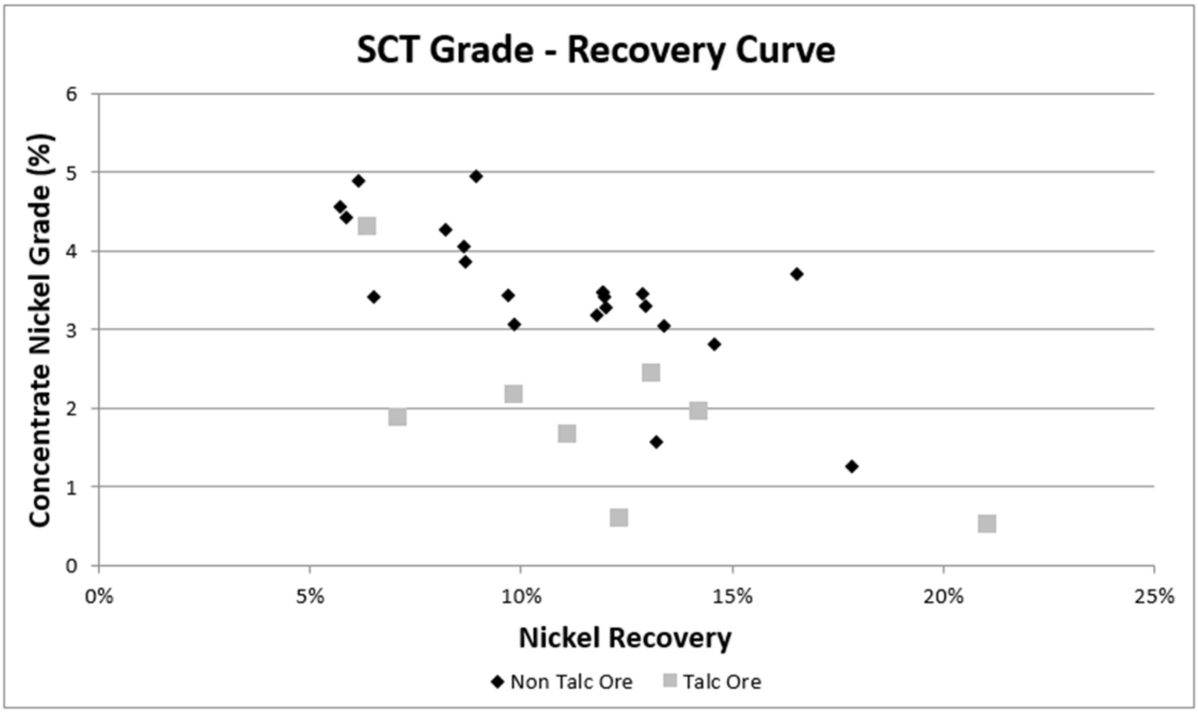

Figure 16 – Cleaner Tailings Grade-Recovery Curve

As with the Slimes Rougher Tailings tests, recovery was calculated using a two-product formula, relying on the feed, concentrate and tail assay data.

The average head grade was 0.37%. The StackCell achieved an average nickel recovery of 10.9%. The average concentrate grade was 3.5%, which is slightly below the upstream cleaner block grade. There were, however, several tests with greater recoveries and grades than these averages, which are perhaps better indications of the potential optimum operating point of this unit.

Tests were included in Trial 2 to determine the performance of the StackCell while treating Talc ore. Due to time constraints and pilot plant commissioning issues, the scope of this talc test work was limited to only 8 tests. The experimental parameters for this test work were generally held similar so as to allow for comparison of these results with the original test work.

The grade recovery results of the talc ore tests are shown in Figure 16, alongside the original non-talc test results. The talc ore results can be seen to fit approximately within the non-talc test results, with slightly lower grades for equivalent recoveries.

Parameter analysis

As with the Slimes Rougher Tailings duty tests, the results of the parameter sensitivity tests are presented below alongside the full data set, for comparison. Note that these are for the non-talc Cleaner Tailings duty tests only, as additional parameter sensitivity tests were not included in the scope for the talc test work.

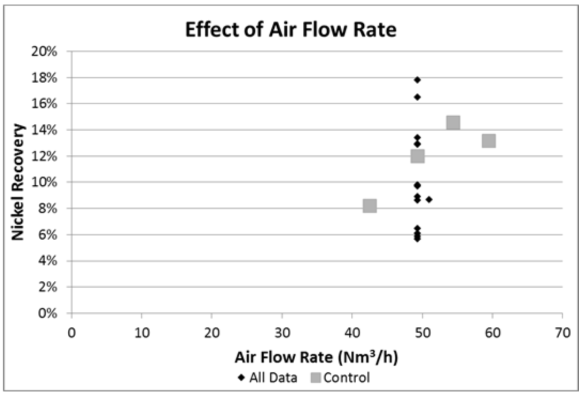

Figure 17 - Cleaner Tail, Recovery vs Air Flow

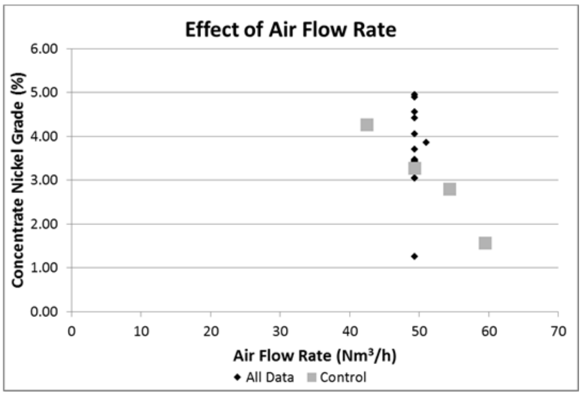

Figure 18 - Cleaner Tail, Grade vs Air Flow

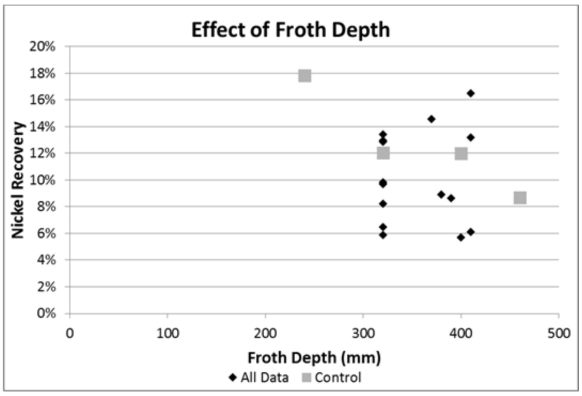

Figure 19 - Cleaner Tail, Recovery vs Froth Depth

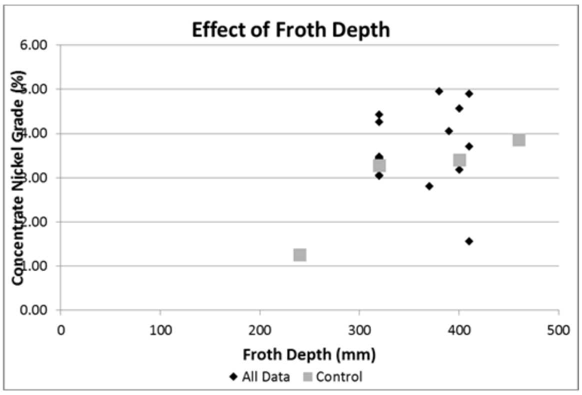

Figure 20 - Cleaner Tail, Grade vs Froth Depth

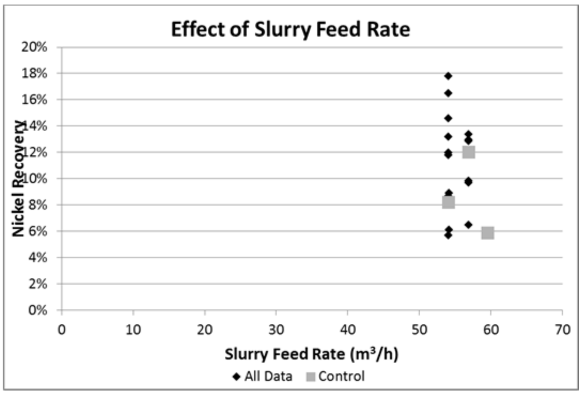

Figure 21 - Cleaner Tail, Recovery vs Feed Rate

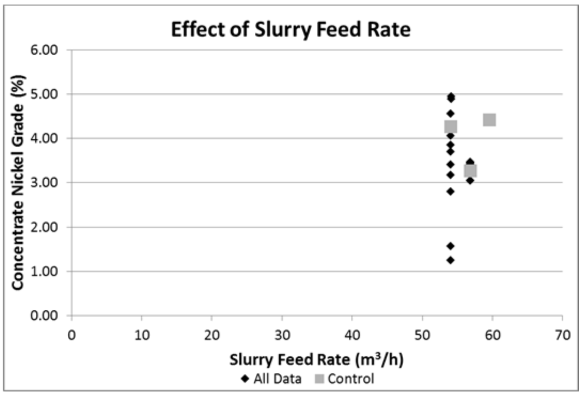

Figure 22 - Cleaner Tail, Grade vs Feed Rate

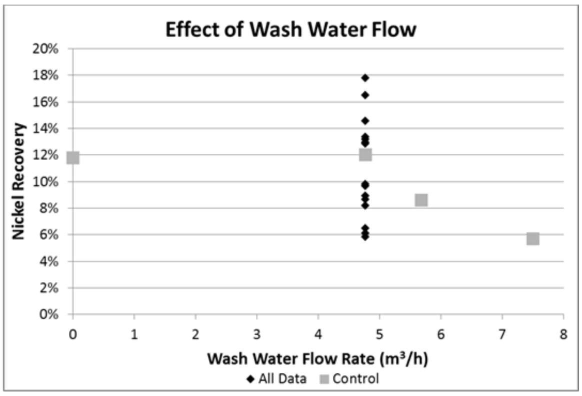

Figure 23 - Cleaner Tail, Recovery vs Wash Water

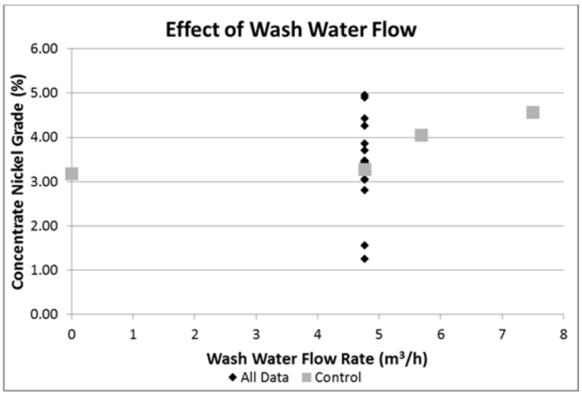

Figure 24 - Cleaner Tail, Grade vs Wash Water

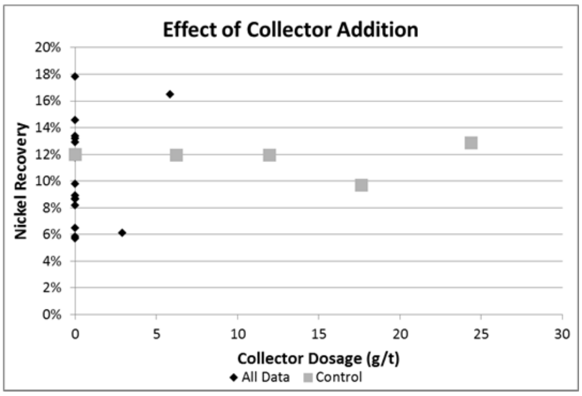

Figure 25 - Cleaner Tail, Recovery vs Collector

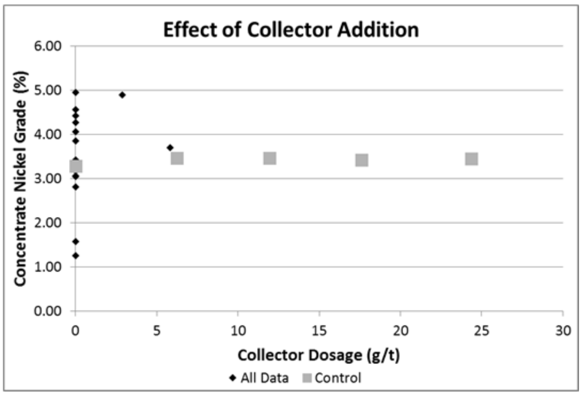

Figure 26 - Cleaner Tail, Grade vs Collector

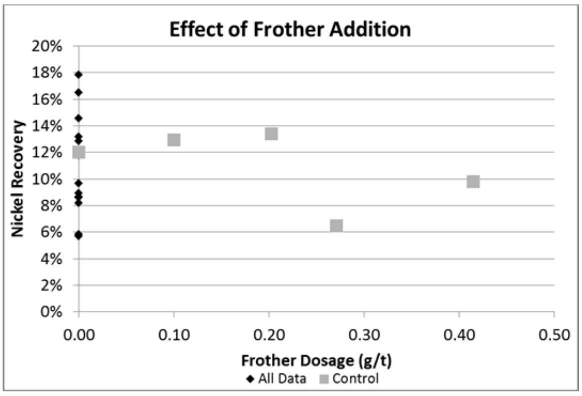

Figure 27 - Cleaner Tail, Recovery vs Frother

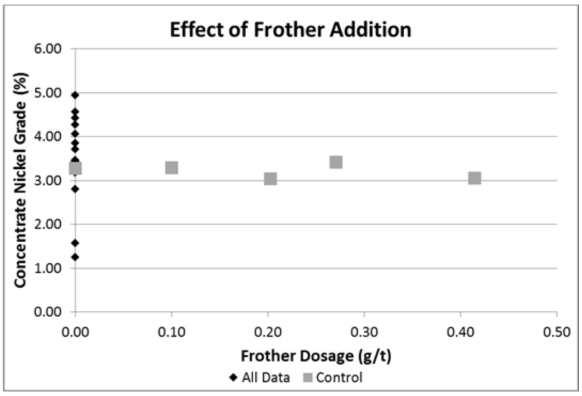

Figure 28 - Cleaner Tail, Grade vs Frother

Cleaner scalper duty

Grinding media in StackCell

Trialling the StackCell in a cleaner-scalper duty was included in the December 2016 experimental scope. During this test work, only one test could be completed as 15 mm grinding media from the immediately upstream tower mill had reported to the StackCell via the StackCell feed point at the head of the Secondary Cleaners. This media caused the intricate StackCell mixing mechanism to jam. As the clearance in the mixing mechanism for conventional flotation is generally greater than that of the StackCell, this issue is unique to the StackCell. The small stator-rotor clearance in the StackCell is required for the characteristic high intensity mixing, therefore removal of foreign media should be considered in industrial StackCell applications. It should be noted that these issues were observed with the 1.2 m pilot unit, and larger StackCell units may have sufficiently large stator-rotor clearance that this issue does not materialise.

Grade recovery curve

After Trials 1 and 2, Trials 3 and 4 were completed to allow for analysis of the StackCell in a cleaner scalper duty. Specifically, the StackCell pilot feed was taken from the discharge of the Tower Mill feed pump and Tower Mill cyclone overflow pump. Although there still existed the potential for grinding media to report to these locations, it would not accumulate there – therefore so long as the cyclones were not blocked during StackCell operation, the risk of grinding media reporting to the StackCell was low. This proved to be a sound method, as no grinding media issues were observed during these tests.

The Tower Mill feed and product streams were both tested, to quantify performance on both. The Tower Mill feed stream had the benefit that the risk of grinding media reporting to the StackCell was eliminated, whereas the Tower Mill product stream had the potential benefit of greater metallurgical performance due to greater liberation.

Guar is commonly used as a talc depressant when treating talc ores at Mt Keith. Several tests dosed guar to the StackCell feed to determine the impact of this reagent on StackCell performance. These tests are highlighted in Figure 29.

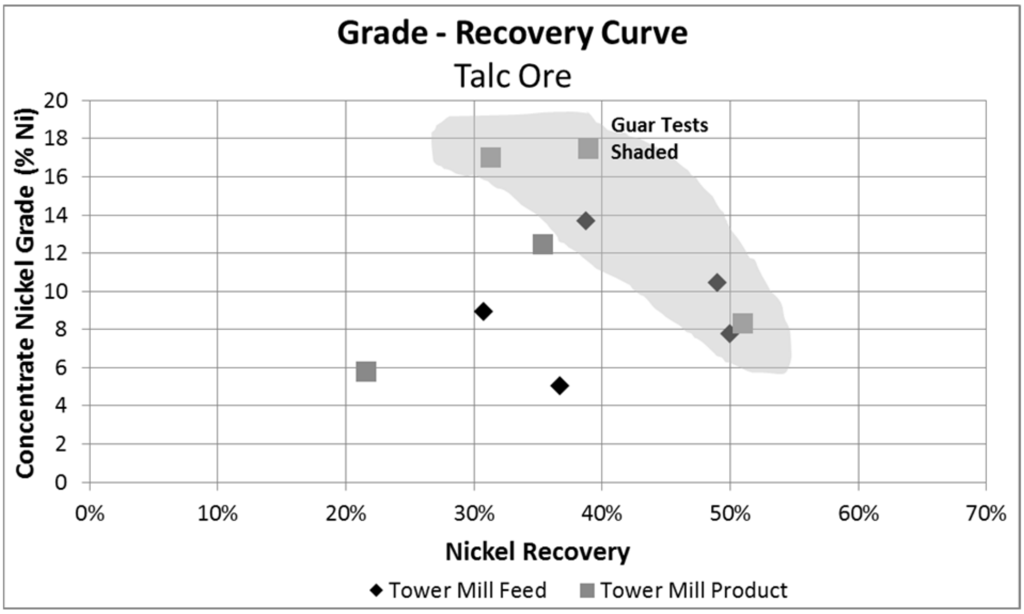

Figure 29 - Tower Mill Grade - Recovery Curve, Talc Ore

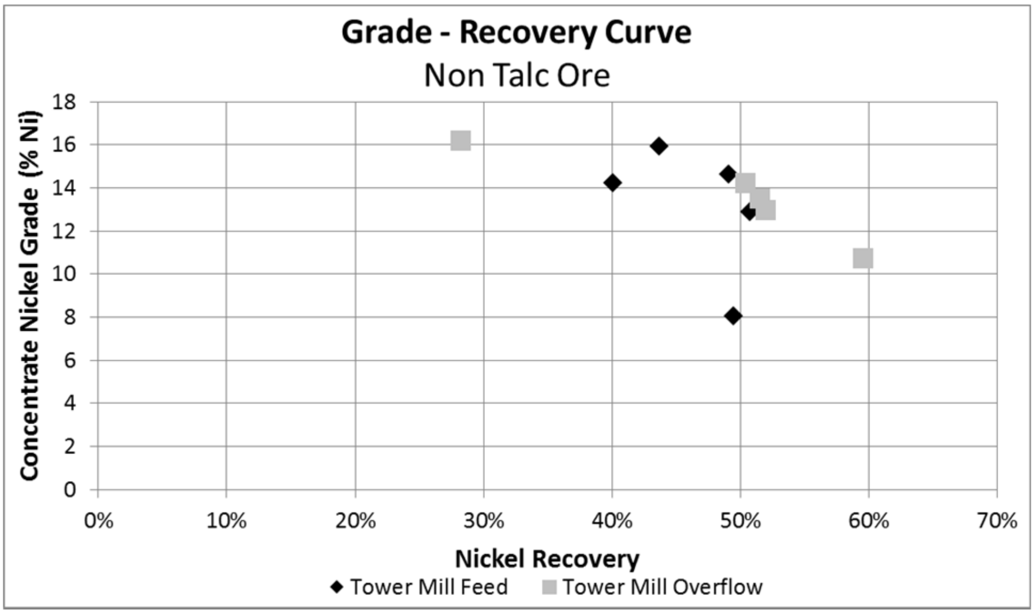

Figure 30 - Tower Mill Grade - Recovery Curve, Non-Talc Ore

The StackCell appears to be very capable of performing in a cleaner scalper duty ahead of the Secondary Cleaner Recleaners. The grade recovery curves for both talc and non-talc ore, Figure 29 and Figure 30, both demonstrate that the StackCell is capable of producing concentrate of sufficient quality to proceed directly to final concentrate, at a remarkably high unit recovery.

By using the StackCell in a final concentrate producing duty, it eliminates the need to refloat StackCell concentrate via downstream conventional flotation.

Effect of guar

The talc ore tests which used guar are highlighted in Figure 29. Although this is a limited data set, it can be seen that they sit at higher grades and recoveries than the non-guar tests. Based on this, it was recommended that any final installation include consideration of a guar dosing system to ensure optimum performance on talc ores.

Tower mill feed vs tower mill overflow

The two StackCell feed streams were compared. There does not appear to be a difference in StackCell performance based on which stream is being treated. Based on this, it was recommended that the Tower Mill feed be considered the preferential location. This is due to the issues observed in previous test work with tower mill media jamming the high intensity mixing mechanism in the StackCell. Eliminating the possibility of tower mill media reporting to the StackCell by positioning the StackCell upstream of the Tower Mill eliminates this risk, and the need for media screening equipment in the StackCell feed line.

Downstream floatability of StackCell concentrate

As this flotation technology differs from the existing, conventional flotation at Mt Keith, the metallurgy team identified the risk that StackCell concentrate may not be fully recoverable via conventional flotation. If this were true, it would limit the StackCell to being used to produce final concentrate, i.e. concentrate that does not require additional treatment in conventional flotation cells.

In order to better understand the floatability of the StackCell concentrate in conventional flotation cells, a laboratory scale conventional flotation test was conducted on the Secondary Cleaner Tailings (i.e. StackCell pilot plant feed for the Cleaner Tailings duty tests) and on the StackCell concentrate from these tests.

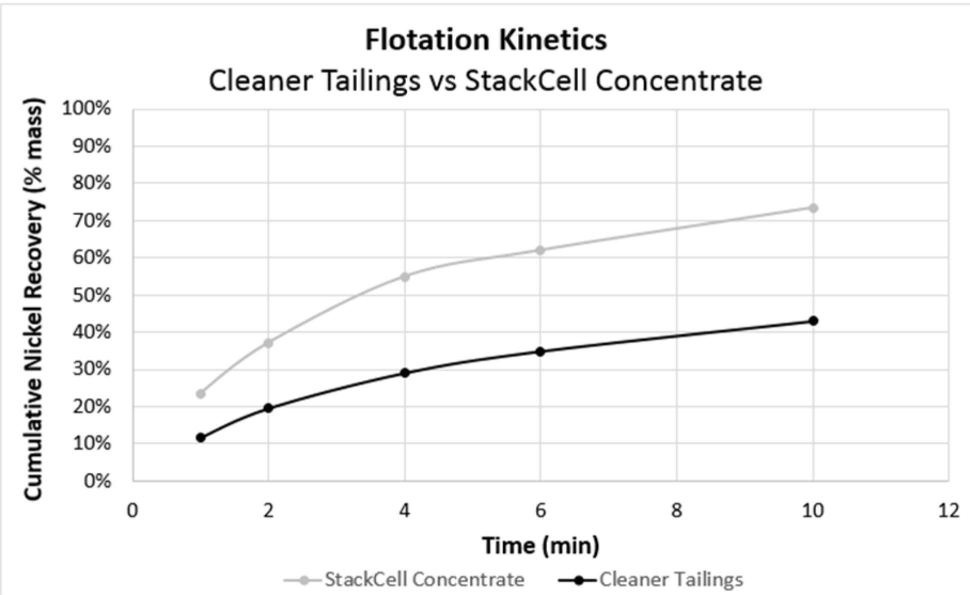

Figure 31 - Flotation Kinetics

It can be seen in Figure 31 that the nickel recovery of the StackCell concentrate test was greater than 20% at 1 minute, and greater than 70% at 10 minutes. This good initial and ultimate recovery indicates that the StackCell concentrate is floatable by conventional flotation and that the StackCell is not floating material that isn't floatable by conventional flotation, it is just doing so at a higher kinetic rate.

Also included is the Cleaner Tailings kinetic results. This stream was feeding the StackCell at the time, so is not intended for relative performance comparison, but rather as point of reference for a similar, but lower grade stream.

Cleaner recleaner block laboratory tests

In order to determine the net economic benefit of the proposed plant arrangement, the benefit of the StackCell would need to be offset against the diminished benefit of the downstream Secondary Cleaner/Recleaner block (as the StackCell would be scalping concentrate, the feed to the Secondaries would be lower quality, and therefore the block performance diminished).

Experimental scope

Four pairs of flotation tests were completed, each with a different combination of ore type and process stream feeding the StackCell.

- Talc ore – Tower Mill feed
- Talc ore – Tower Mill product
- Non-talc ore – Tower Mill feed
- Non-talc ore – Tower Mill product

The intention of these flotation tests was to simulate the Cleaner Recleaner block performance, so that a mass balance of the proposed StackCell circuit could be generated, and the net benefit of the StackCell in a cleaner scalper duty could be analysed.

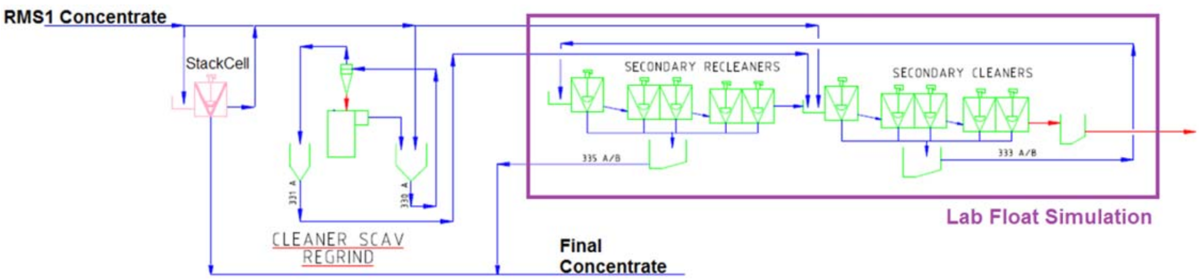

Figure 32 - PFD for laboratory flotation test

Experimental procedure

For each of these tests, StackCell feed and tailings samples were collected. These samples were subjected to a 14 minute 'cleaner' flotation test. The concentrate produced was collected as a bulk concentrate, and then further subjected to a 14 minute 'recleaner' flotation test. The concentrate from this test was collected in several stages.

- Stage 1: 0-2 minute concentrate
- Stage 2: 2-4 minute concentrate
- Stage 3: 4-8 minute concentrate
- Stage 4: 8-14 minute concentrate

Experimental results

In order to quantify the performance of the Secondary Cleaner Recleaner block while treating StackCell tailings, laboratory scale flotation tests were conducted on StackCell tailings from tests 3, 13, 23 and 35. Each of these tests had consistent StackCell operating parameters.

Table 4 – Cleaner Recleaner Block Simulation Tests

Lab flotation test sample collected during test #	Ore Type	StackCell Feed
3	Talc	Tower Mill feed
13		Tower Mill product
23	Non-talc	Tower Mill product
33		Tower Mill feed

To calculate the combined StackCell & Secondaries block recovery, both the StackCell and Secondary Cleaner Recleaner block recoveries were required.

Talc ore

As can be seen in Table 5, there was a slight overall recovery improvement when the StackCell was included in the circuit.

Table 5 – Talc Ore Recleaner Lab Flotation Test Recovery Benefit

StackCell	Block Recovery	GM501 Feed	GM501 Product
On	StackCell	49.0%	38.9%
	Cleaner/ReCleaner	61.3%	61.3%
	Combined	80.3%	76.4%
Off	Cleaner/ReCleaner	79.6%	75.1%
	Recovery Benefit	0.7%	1.2%

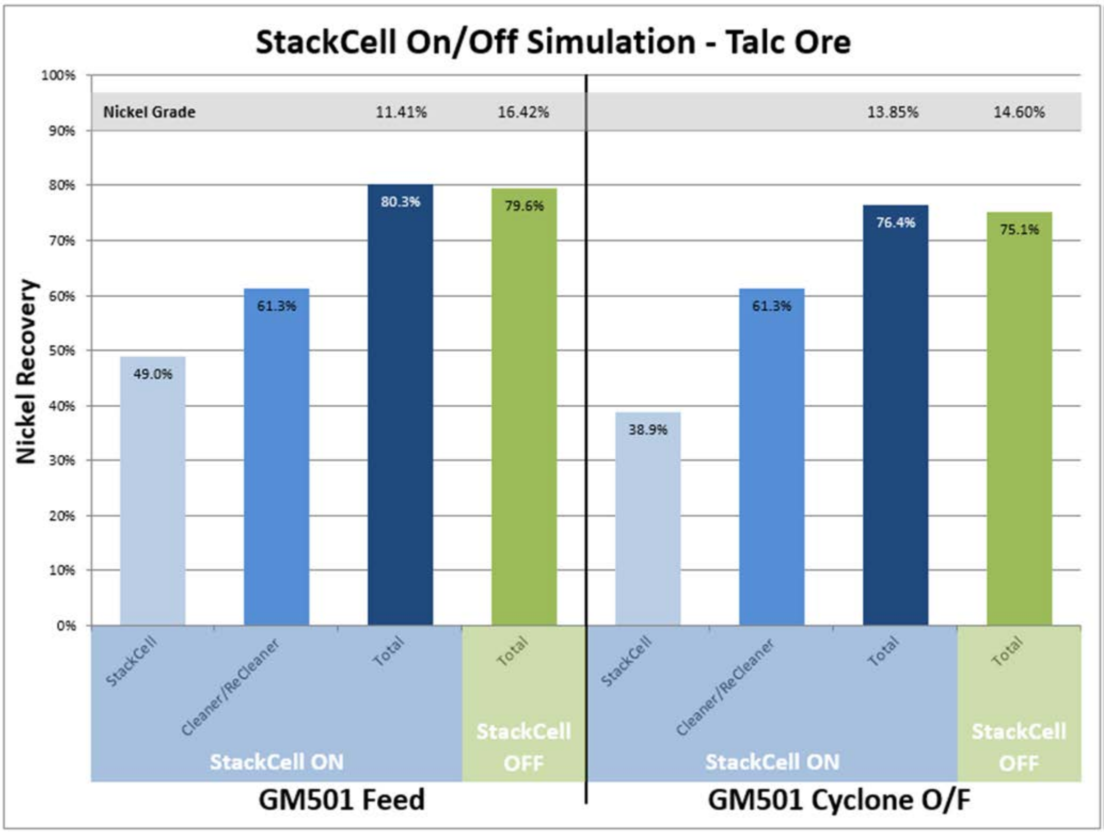

Figure 33 - Talc Ore Recleaner Lab Flotation Test Recovery Benefit

Non-talc ore

As can be seen in Table 6, the Tower Mill feed test achieved an overall improvement with the StackCell, however the Tower Mill product test work showed poorer recovery. Confidence in this Non-Talc, Tower Mill product test is low, due to issues with this laboratory test.

Table 6 – Non-Talc Ore Recleaner Lab Flotation Test Recovery Benefit

StackCell	Block Recovery	GM501 Feed	GM501 Product
On	StackCell	49.1%	50.3%
	Cleaner/ReCleaner	56.5%	72.6%
	Combined	75.5%	80.3%
Off	Cleaner/ReCleaner	73.5%	82.8%
	Recovery Benefit	2.0%	-2.5%

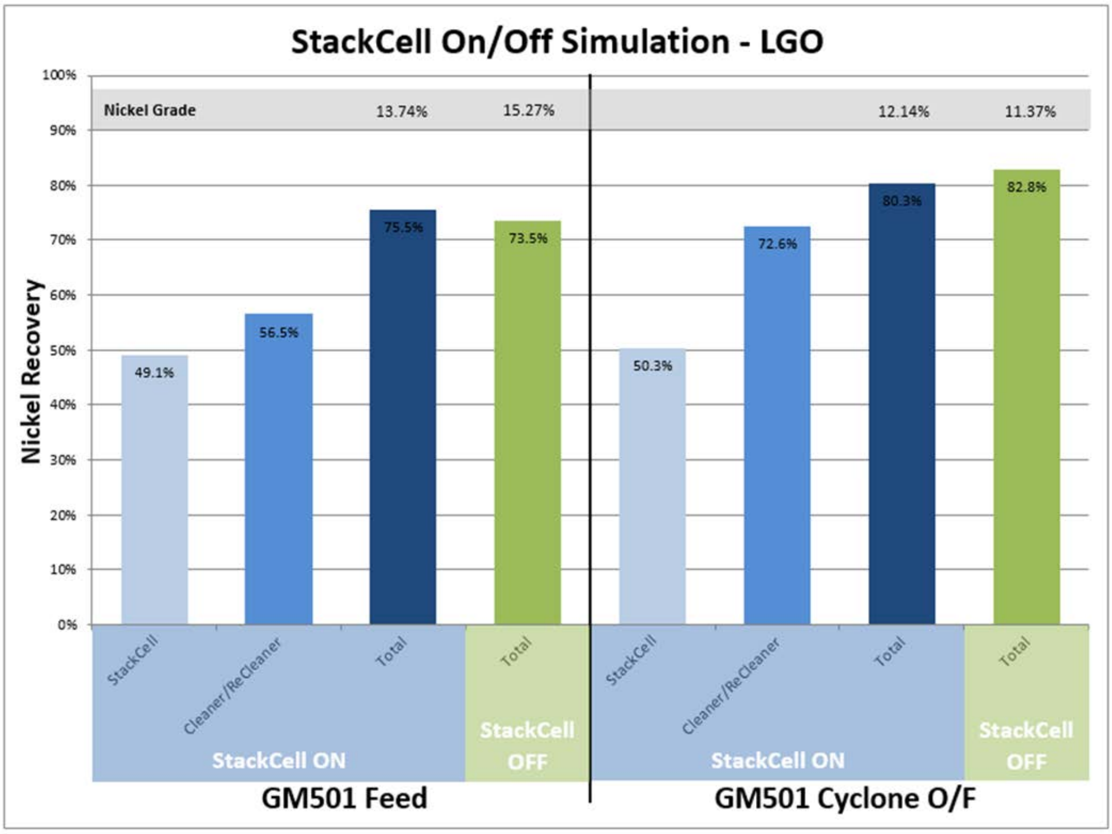

Figure 34 - Non-Talc Ore Recleaner Lab Flotation Test Recovery Benefit

Of the four tests completed, three demonstrated that the inclusion of a StackCell in a cleaner scalper duty would improve the recovery of this block. The fourth result indicated a negative benefit, however confidence in this test was low due to issues with the laboratory results.

These recovery improvements were accompanied by a drop in grade. It is possible that these tests simply traded concentrate grade for an increased recovery, and did not actually achieve an increase in metallurgical performance. Unfortunately, due to resource and time constraints, additional test work to investigate this relationship was not able to be completed.

StackCell vs conventional flotation

Slimes rougher tailings - Trial 1

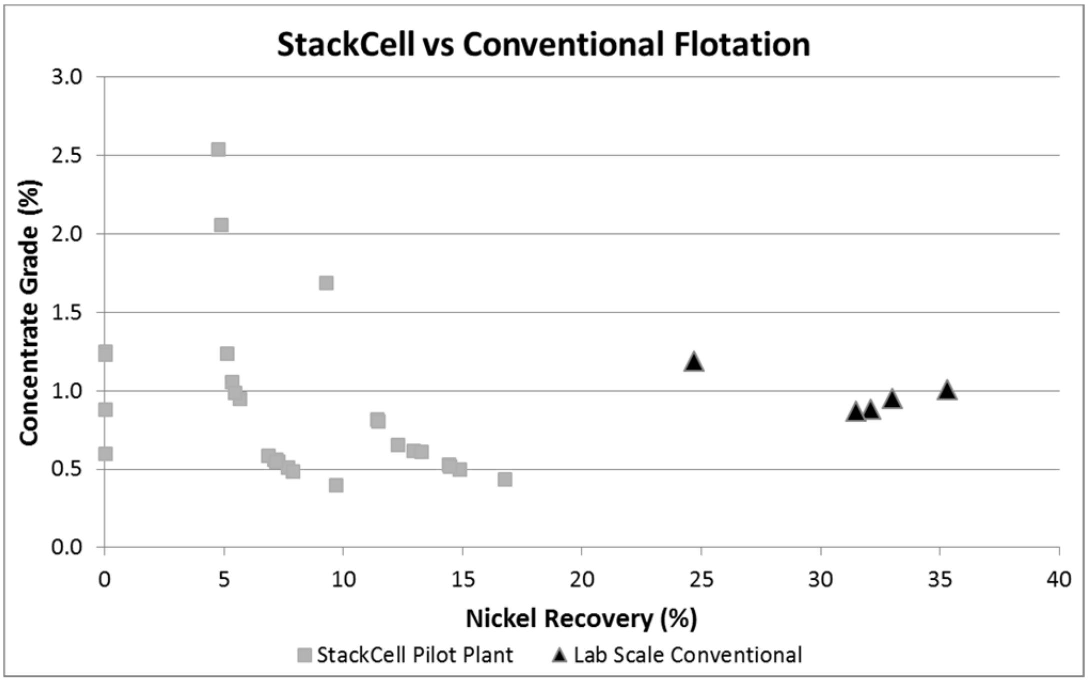

Figure 35 – Slimes Rougher StackCell vs Conventional Flotation

During the StackCell pilot scale test work, site-standard daily laboratory scale conventional flotation tests were completed on the Slimes Rougher Tailings stream. The laboratory tests were completed once each day, and therefore did not align with any particular StackCell pilot test. The plant was stably treating comparable ore, so these tests can be used as a general comparison between the relative performance of StackCell and conventional flotation.

In general, the StackCell was capable of achieving about half the recovery of the conventional flotation tests, with a comparable grade.

Given that these conventional tests were 8 minute batch tests, and assuming a lab to plant scale up factor of 2, these lab tests are assumed to represent an additional 16 minutes of plant scale conventional flotation. As per Table 3, the contact time in the StackCell for Trial 1 was 55 seconds, significantly less than 16 minutes (960 seconds). This indicates that the StackCell kinetics exceed that of conventional flotation.

The StackCell data set presented in Figure 35 can also be seen in Figure 3, accompanied by an explanation of the unusual grouping of grade-recovery data.

Secondary cleaner tailings – Trial 2

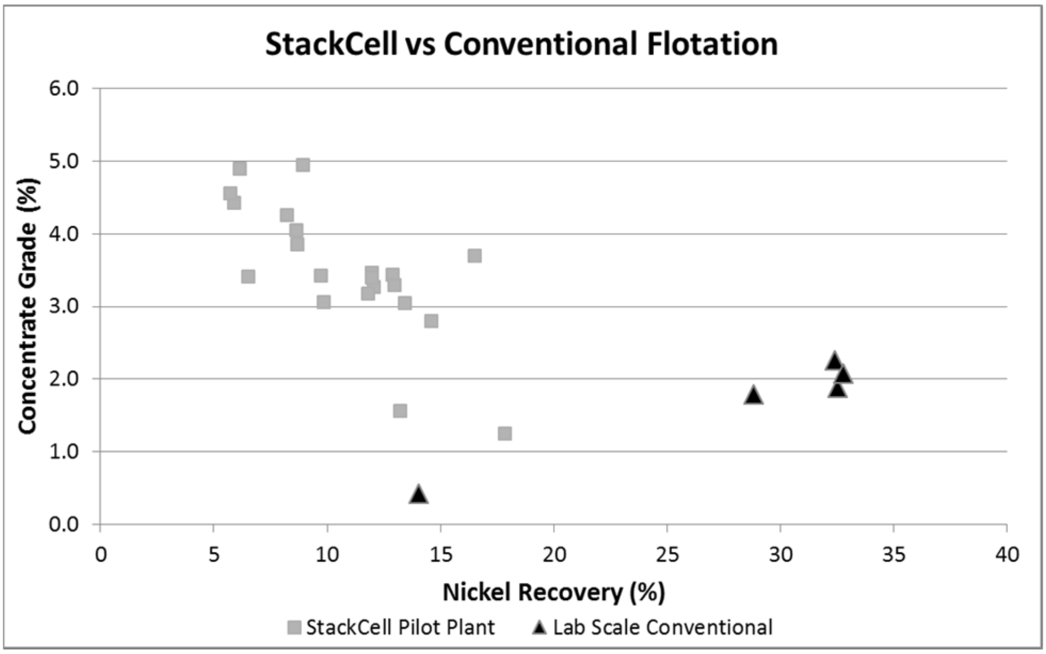

Figure 36 – Cleaner Tailings StackCell vs Conventional Flotation

In general, the StackCell achieved 30-50% of the nickel recovery of the conventional laboratory tests, however this was accompanied by a 50-150% greater concentrate grade.

As per Table 3, the contact time in the StackCell for Trial 2 was 93 seconds, significantly less than 16 minutes (960 seconds). This indicates that the StackCell kinetics exceed that of conventional flotation.

CONCLUSIONS

Pilot scale test work was completed at the Mt Keith Nickel Concentrator to quantify the benefit of the StackCell technology while acting in a rougher scavenger, cleaner scavenger and cleaner scalper duty. A wide variety of operating points were tested, giving information as to the optimum operating conditions, and sensitivity to each parameter.

A single StackCell unit was able to achieve up to 16.8% nickel recovery when acting in a rougher scavenger duty, at grades consistent with that block. When acting in a cleaner scavenger duty, 16.5% nickel recovery was achievable, although this was at a slightly lower grade than the cleaner block. These single stage recoveries are especially impressive given that they were achieved with a contact time of 55 and 93 seconds, respectively. Laboratory scale tests conducted concurrently with these tests indicated that the StackCell could achieve up to half the recovery of a conventional flotation cell that had 960 seconds of residence time. This is a significant improvement in flotation kinetics.

When operating in a cleaner scalper duty, the StackCell achieved maximum nickel recovery of 59.5%. The net effect of utilising a StackCell in the middle of the process was estimated with a lab scale on/off trial which simulated the downstream cleaner recleaner block performance. This analysis indicated an overall net benefit of 0.7% - 2.0% for this block. This represents an economically significant nickel metal yield, and therefore an industrial scale installation is being considered.

In some tests, tramp metal reported to the StackCell, causing operational issues within the intricate mixing mechanism. This is expected to be less critical at larger scales, where rotor-stator clearances are greater, however this should still be addressed.

Laboratory scale test work indicated that concentrate produced by the StackCell could be floated via additional, downstream conventional flotation.

This test work provided good initial pilot scale data to support the use of this technology in sub 40 µm sulfide flotation. Further optimisation of this technology will certainly improve on these results, and on the historical industry performance in floating this material.

ACKNOWLEDGEMENTS

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