COLUMN FLOTATION IN THE ATHABASCA OIL SANDS
ENHANCED BITUMEN RECOVERY AT LOW COST

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ABSTRACT

The Athabasca Oil Sands deposits of Northern Alberta, Canada, represent one of the largest petroleum reserves in the world. The current bitumen extraction process generates a middlings stream that contains recoverable bitumen along with significant clay slimes. Mechanical flotation, presently in use, is inefficient at removing the slimes, which build up in the circuit and reduce capacity. In 2002, CPT and Eriez demonstrated that a pilot column flotation cell was able to match the bitumen recovery of mechanical cells while significantly reducing slimes entrainment. A full size installation is planned to demonstrate the process on a commercial scale.

INTRODUCTION

The Athabasca Oil Sands deposits of Northern Alberta, Canada, represent one of the largest petroleum reserves in the world. The total reserves are estimated to be larger than those of Saudi Arabia. The oil in this world-class deposit, however, will be hard won. The petroleum occurs as bitumen, a heavy tar-like substance, in a matrix of sand and silt, with some water. Recovery is further complicated by the severe sub-arctic climate of northern Alberta, where winter temperatures can dip to -45 degrees Celsius.

The water content, so-called connate water, surrounds each grain of sand, and the existence of connate water is one of the features of this deposit that makes the oil recoverable. It allows the bitumen to be separated from the sand, although with some considerable effort.

The Current Process

The oil sands are mined with conventional surface mining methods, using either draglines and bucket-wheel excavators (in declining use) or truck and shovel (more common today). The oil sands are first slurried by mixing with hot water, typically in rotary breakers that serve both to reduce the coarse material to a consistency that can be pumped, and also to entrain a certain amount of air.

Next, the oil slurry is pumped some distance to primary separation. This pumping phase has recently been discovered to be very beneficial to separation, and indeed, pumping distances are intentionally increased to give the slurry more time in the pipeline. This process is called hydro-treating.

Next, the hot slurry, containing about 12% bitumen, is introduced into large, conical bottom Primary Separation Vessels (variously called PSV's, PSC's and Sep Cells) where the relatively quiescent conditions and entrained air allow the bitumen to separate, and the majority of the bitumen "floats" to the surface for recovery as a froth containing about 60% bitumen. The underflow from these gigantic separation vessels consists mainly of sand, clays and water with trace amounts of residual bitumen.

The separation process, however, is unfortunately not as simple as this.

Through long experience, oil sands operators have found that in order to achieve acceptable bitumen recovery in the Sep Cell, with acceptably low levels of clay contamination of the primary froth, it is necessary to remove a "middlings" stream from within the Sep Cell. At Suncor this middlings stream is presently treated in conventional mechanically agitated flotation cells to recovery residual bitumen and to reject clay fractions. The mechanical cell froth is recirculated to Sep Cell feed and if clay fractions are not controlled they build up in a circulating load that can reduce Sep Cell throughput.

It is the treatment of this middlings stream that is the subject of this paper.

Middlings Flotation

Canadian Process Technologies of Vancouver, BC, Canada, has developed column flotation for oil/water separation (VOSCell) and, in partnership with Eriez Magnetics of Erie, PA, USA, has also developed column flotation for fine coal recovery (CoalPro). In 2002, the decision was made to advance column flotation technology in the Athabasca Oil Sands by applying our combined knowledge and expertise in column flotation testing, scale-up, design and operation.

Several Oil Sands operators were approached, and Suncor Energy Systems agreed to support a pilot scale column flotation test program. Column flotation had been tested in previous years with limited success but CPT/Eriez felt that current technology might be able to provide a break-through. A field-proven 0.5 m (20 inch) diameter pilot scale column cell was available, and was relocated to the Suncor site to test flotation of their Line 6 Sep Cell Middlings.

Initial testing in the 0.5 m diameter cell was very encouraging, and led to a second phase of testing using a much larger 1.22 m (48 inch) diameter cell. In both test programs, performance of the pilot scale column cell was systematically compared to performance of the existing mechanical flotation cells. The trials and tribulations of plant scale testing, and the very encouraging results, are described in the following pages.

ASSEMBLING THE TEST EQUIPMENT

Phase One – 0.5 m Diameter Column

The pilot column cell, supplied by Eriez Magnetics, was 0.508 m (20 inches) in diameter and 3.66 m (12 feet) high, fitted with a conical bottom discharge and an external overflow launder. The wash water distributor was a simple perforated PVC pipe ring with manual height adjustment, allowing wash water to be administered above or submerged within the froth. The column featured the ability to evaluate both air-only jetting spargers (CPT SlamJet) and an externally pumped recirculation sparger (CPT Cavitation Tube Sparger).

The froth-pulp interface location was measured with a single pressure transducer, and level was controlled with a single-loop PID controller modulating the opening of an air-actuated underflow valve. Air and wash water flows were manually adjusted and monitored using simple rotameters.

Feed System: Laboratory and pilot scale testing, in order to be relevant and reliable, as is well known, depend absolutely on having a representative feed sample. In the case of pilot testing at Suncor, the existing mechanical flotation cells receive feed through a 0.61 m (24 inch) diameter pipeline at a rate of about 1,590 m^3/h (7,000 USGPM). The appropriate feed rate for the 0.5 diameter pilot column cell is about 5.7 m^3/h (25 USGPM). The problems associated with extracting a representative 6 m^3/h sample from a 1,600 m^3/h pipeline were formidable. The phrase "sipping from a fire hose" comes to mind. Added to this fundamental problem was the existence of tramp oversize in the form of coal-like lumps of petrified material. The presence of this material was controversial, and the oversize pieces were dubbed "virtual" rocks.

The available access to the 0.61 m diameter scavenger feed pipe was a 10 cm (4 inch) diameter nozzle. The feed pipe was rubber lined, so modifications that would damage this lining, such as cutting and welding to insert a different size nozzle were, to say the least, discouraged. Therefore, a simple first attempt was made by fitting a 10 cm ball valve and 10 x 5 cm reducer to the nozzle. When the ball valve was throttled to provide 6 m^3/h, it plugged immediately and without delay.

Next, a modified thief sampler was tried. A 5 cm diameter extractor pipe, cut away to a half-pipe and oriented with the closed side facing upstream to prevent collection of oversize, was inserted into the stream. This system, when throttled, plugged immediately and without delay.

It was becoming obvious that throttling the flow was not a viable option and an external method to remove oversize would be needed. Suncor displayed exceptional patience and cooperation, and agreed to manufacture a sieve bend. With un-throttled full flow through the extractor pipe as feed to the sieve bend, the problem of "virtual" rocks was virtually eliminated.

This system worked acceptably well and allowed test runs of several hours, as compared to the previous standard of several minutes. It proved very difficult to regulate the feed rate to a pre-determined flow however, as flow adjustment was made by reaching beneath the sieve bend, in the presence of a continuous rain of hot bitumen splash, to move a ball valve handle with a shovel handle. In spite of this minor inconvenience, a series of tests with acceptable feed rates was performed. Results of these tests, detailed later in this report, were very encouraging, and led to the decision to continue testing in the much larger 1.22 m diameter test cell.

Phase Two – 1.22 m Diameter Column

A 1.22 m (48 inch) diameter by 7.62 m (25 foot) high portable column cell was available for testing. This CPT test cell began life as a carbon pre-float cell at the Red Dog operation in Alaska. The original flat-bottom design was modified to incorporate a 60-degree conical bottom to accommodate the coarse and fast-settling nature of oil sands. The pilot column featured an internal feed distribution assembly, a small internal froth launder in addition to the usual external launder, and a height-adjustable wash water distributor comprising a simple perforated PVC ring assembly. As with the smaller cell, interface level was detected using a single pressure transducer, level was controlled with a single-loop PID controller and an air-actuated underflow pinch valve, and air and wash water flows were manually adjusted. Air flow rate was measured with a rotameter and wash water flow rate was measured with a paddle-wheel flowmeter.

This pilot column was installed in place of the 0.5 m cell, taking advantage of the proximity of a feed source and of suitable locations for disposal of froth and tails.

The "comfortable" feed rate for this column was in the order of 23 m^3/h (100 GPM). For this flow rate, the sieve bend designed for testing of the 0.5 m diameter test cell proved inadequate – so the process of arranging for a reliable feed began anew.

The extractor pipe was removed from the scavenger feed pipe, and the ball valve and reducer were used to feed the column directly. This system, when throttled, plugged immediately and without delay.

Next, the 10 cm outlet from the ball valve was expanded to a 15 cm diameter manifold, and the end of this manifold was "vented" with a 15 cm diameter flexible hose draining back to one of the mechanical cell feed boxes. This system allowed full flow through the extractor and ball valve followed by a significant reduction in both velocity and pressure. A 15x5x15 cm Tee and a 5 cm throttling valve were added to the manifold as an off-take to feed the column. This system, when throttled, plugged almost immediately and with some delay.

Next, the manifold, which was assembled with a number of Victaulic couplings, was modified by inserting a 15x15x15 cm Tee to provide a second 15 cm manifold outlet which was also piped back to the mechanical cell feed box. This arrangement allowed a further reduction in pressure in the manifold. In addition, three small 6 mm bars were welded across the 5 cm outlet to form a "screen" across the outlet. These bars were curved so as to protrude slightly into the main flow and allow a degree of self-cleaning. This system, when throttled, finally and amazingly, worked just fine, and testing of the 1.22 m cell began apace.

Test Procedures

For testing in both the 0.5 m and 1.2 m diameter cells, operating parameters to be evaluated were selected in advance, the column was operated for a minimum of two (2) residence times to insure stable operation, then samples of column feed, concentrate and tails were collected. Care was taken to collect exit streams (concentrate and tails) first, followed by feed, to avoid upsetting column stability. For selected tests, parallel samples of mechanical cell concentrate and tails were also collected to provide a basis for comparison. At the time of sampling, all operational data were recorded, including sparger type, sparger air flow and pressure, wash water flow and pressure, and interface level and PID controller setpoint, along with pertinent visual observations and general circuit conditions.

For selected tests, either the feed flow rate or the tails flow rate was measured manually by directing the stream into a barrel and timing the fill rate.

All samples were submitted for standard oil sands industry analyses, including %Bitumen, %Mineral and %Water. It's important to understand that, in the oil sands industry, water is a contaminant.

TEST RESULTS

Phase One – 0.5 m Diameter Column

A total of 42 tests were performed. The average feed to the column (and mechanical flotation machines) was about 0.35% Bitumen, 38% Mineral and 62% Water. Due to the proprietary nature of the test program, detailed data tables can not be shown, and data analysis will be presented in the form of summary tables and graphs.

The primary objectives of the test program were to determine if column flotation could a) recovery bitumen from Sep Cell middlings with at least the same efficiency as the existing mechanical flotation cells, and b) improve the quality of the recovered bitumen froth by reducing or eliminating entrained mineral and fine clays.

A secondary objective was to determine if column flotation could produce a bitumen froth containing less than 12% mineral. Below this cut-off point, scavenger flotation concentrate can be sent directly to Sep Cell concentrate, thus eliminating the circulating load in the Sep Cell. This possibility has significant implications in regard to Sep Cell capacity.

Results comparing the 0.5 m column cell to the mechanical cells are given in Table 1. Note that because column operation was intentionally pushed to identify operational limits, results ranged from poor to very good. The mechanical scavengers also produced a range of results, but the variations seen here were a result of normal operation. There was no systematic attempt to push performance limits. Therefore, to provide a reasonable basis for comparison, the best three results (best combination of grade and recovery) for each were selected, and averages are shown in the table.

Table 1 – Column vs. Mechanical – Best Three Tests

	Concentrate			Distribution	
	Assays			Bit	Min
	%Bit	%Min	%Wat	Rec%	Rej%
Column	5.0	12.0	83.0	76.5	97.6
Mechanical	4.4	11.5	84.1	51.7	98.3

These data show that the column produced a bitumen froth of similar quality to the mechanical cells, but at significantly higher recovery. This was the most important finding in the small cell test program.

The rejection of mineral to tails was similar in both cases, but the samples were not analyzed for mineral particle size. Based solely on physical appearance of the two froths (column and mechanical), operators at Suncor were of the opinion that the column froth was significantly lower in clay fines. This is a particular advantage of column flotation since middlings froth is recycled to Sep Cell feed, where a circulating load of un-rejected slimes leads to reduced throughput capacity for the Sep Cell.

It should be noted that the mechanical flotation cells normally produce a concentrate with more than 12% mineral and concentrate is therefore recycled to Sep Cell feed.

Sparging System: Three different types of sparger were evaluated in the 0.5 m column test program.

- External Pumped System with in-line cavitation mixer (CPT Cavitation Tube)
- Air-Only Jetting Sparger (CPT SlamJet)

Column Wash Water: Tests were performed initially without wash water, to allow some familiarization with bitumen flotation. In subsequent tests, wash water was administered at varying rates. The temperature of the wash water was also adjusted. In the Suncor plant, water of three temperatures is available – cold (15 deg C), tempered (40 deg. C) and hot (+80 deg. C). Water of all three temperatures was tested. The concern was that, with cold water (least expensive) there was a risk of creating a so-called "formed froth" which can be very difficult to pump. Test results showed that there was no significant difference in column performance. Visual evaluation of the froth did not indicate that a formed froth had been produced with cold water.

In analyzing the test results, and coming from a mineral and coal processing background, the authors found that the usual "grade – recovery" curve often applied to mineral systems did not seem to fairly represent what was happening in the bitumen recovery cells. Given that the objectives of middlings flotation are to recovery bitumen and reject mineral slimes, a "separation efficiency" curve was developed by plotting bitumen recovery as a function of mineral rejection. The results of this method of analysis are presented in Figure 1.

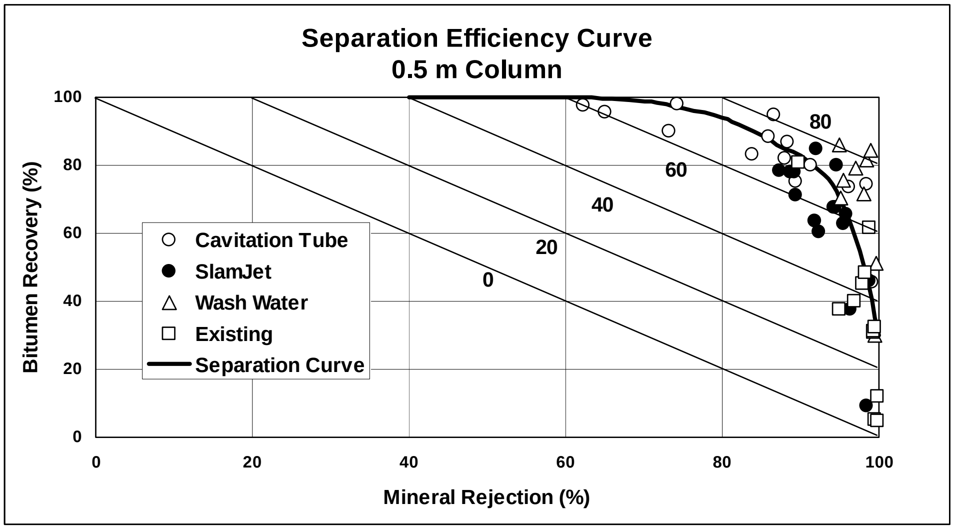

Figure 1 – Separation Efficiency Curve

This method of presenting data is similar to a "release curve" commonly used in coal processing. The diagonal lines indicate the direction of improvement. Note that the "0" line represents "mass recovery", with no separation.

In order to better illustrate the details of this figure, it will be instructive to examine the 80% to 100% Mineral Rejection area in greater detail, as shown in Figure 2.

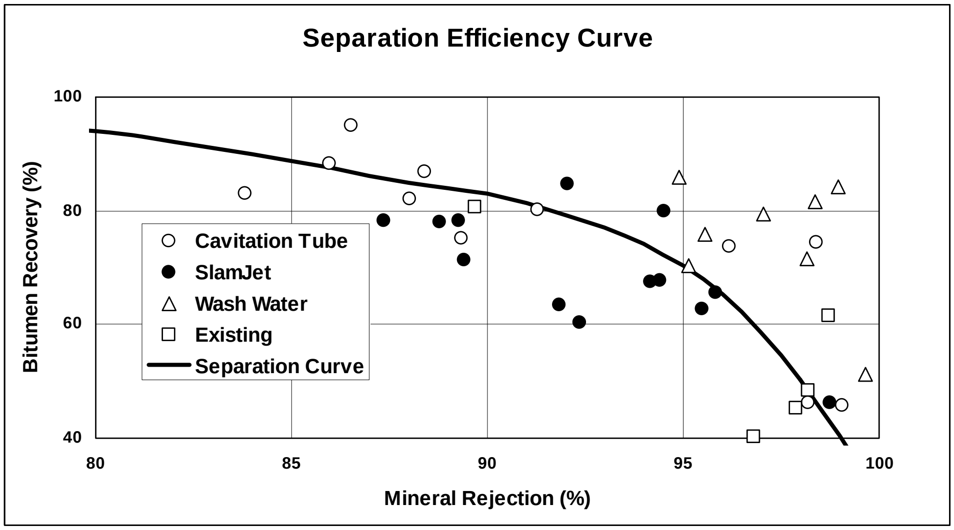

Figure 2 – Separation Efficiency Curve – Closer View

The external pumped sparging system (open circles) produced the highest bitumen recovery. By visual observation, the bubbles generated by this system were clearly the smallest, and as a result, entrainment of fine mineral fractions was highest.

The existing mechanical cells (open squares) achieved the highest mineral rejection, but at a substantially lower recovery.

The SlamJet jetting sparger (closed circles) achieved perhaps the best combination of bitumen recovery and mineral rejection.

The addition of wash water to the column while aerating with SlamJets moved the results to the right (open triangles), providing improved mineral rejection with no loss in bitumen recovery. For mineral rejection values of +90% the column, with air-only SlamJet sparging and wash water addition achieved nearly double the recovery of the mechanical cells.

During testing, as mentioned previously, care was taken to record all pertinent data, to allow detailed examination of the effects of the various column cell parameters on performance. For the 0.5 m column tests, the two most significant parameters, as expected, were residence time and sparger aeration rate.

<u>Nominal Residence Time</u>: Residence time was calculated based on underflow (tailings) flow rate.

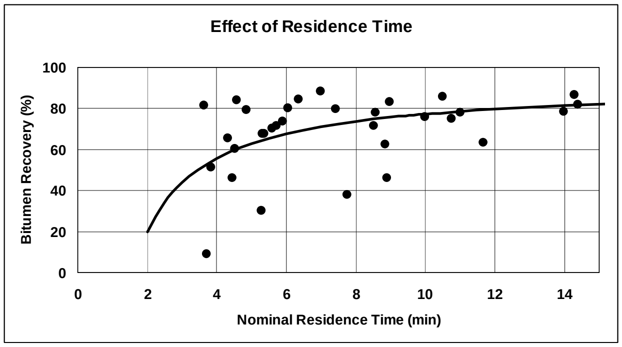

Figure 3 – Effect of Residence Time

The data show a general increase in bitumen recovery with increasing flotation time. Although a few good results were obtained at short times, it should be noted that smaller diameter columns exhibit somewhat less mixing than full size units. For conservative design, a residence time of at least 8 to 10 minutes was selected.

<u>Aeration Rate</u>: The aeration rate, or gas rate (J_g), as is customary in column flotation design, is expressed in terms of Superficial Velocity, which is the volumetric flow rate of gas divided by the column vessel cross-sectional area, with units of cm/s. The advantage of this method is that it is independent of column diameter and can thus be applied to any diameter of column.

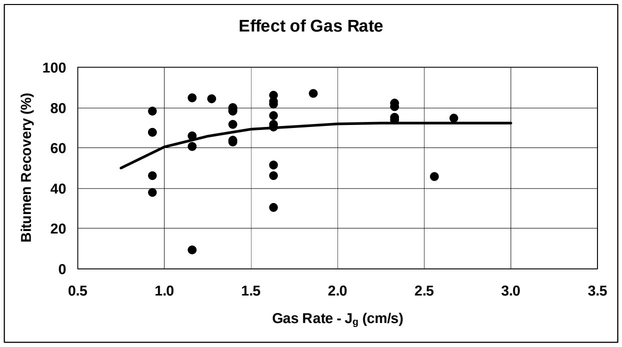

Figure 4 – Effect of Gas Rate

Again, good results were achieved over a range of gas rates. For the 0.5 m cell, a gas rate of 2.0 cm/s would be selected in order to ensure optimum bitumen recovery.

The gas rate had no well defined effect on the mineral content of concentrate, the water content of concentrate or mineral rejection to tails. Intuitively, a higher gas rate should result in increased entrainment of mineral and water in the concentrate.

Feed Bitumen Grade: It was reasoned that a higher feed grade of bitumen would result in a higher concentrate grade. The data show no significant correlation. The feed grade ranged from about 0.2% to 0.6% Bitumen, averaging 0.35% Bitumen, and the concentrate ranged from 0.4% to 8.0% Bitumen, averaging 2.1% Bitumen.

Feed Mineral Grade: The mineral content of the feed varied over a wide range, and it was also thought that the mineral content of the feed may influence the mineral content of the concentrate or the mineral rejection. Again, the data show no significant correlation. The feed grade ranged from about 28% to 56% Mineral, averaging 38% Mineral. The concentrate ranged from about 4% to 18% Mineral, averaging 11.8% Mineral.

Carrying Capacity: Column cell design often reduces to determining if the process is residence time limited (cell volume) or carrying capacity limited (cell area). Carrying capacity (C_a) is a measure of the column's ability to transport material out of the column. It is commonly expressed in terms of tones per hour of concentrate solids per unit of column cross-sectional area, or t/h•m^2. Note that this term is also independent of column diameter. In the case of bitumen flotation, the "solids" includes grains of mineral plus droplets of bitumen.

For the 0.5 m cell, the C_a ranged from 0.15 to 2.8 t/h•m^2, averaging about 0.8 t/h•m^2. These values are very much in line with typical coal flotation. Test results indicate that column cell design for bitumen flotation will be carrying capacity limited. This means that when the cell diameter has been selected to provide sufficient carrying capacity, the cell height required to meet residence time requirements will be within acceptable limits – neither excessively short or tall.

As mentioned earlier, these test results, as well as the design parameters indicated, were very encouraging. It appeared that column flotation could provide improved bitumen recovery and, at the same time, might be able to produce a concentrate with a mineral content low enough the allow elimination of scavenger froth recycle.

Given the enormous scale of operations in the Athabasca Oil Sands, it comes as no surprise that our 0.5 m column cell was viewed as somewhat tiny. Although Suncor was pleased with the test results, there remained a healthy skepticism about scaling up to full commercial size units from this "toy" column. Therefore, a 1.22 m diameter portable column cell was made available for confirmatory testing.

Phase Two – 1.22 m Diameter Column

On the basis of flotation column area, the key parameter for a carrying capacity limited design, the 1.22 m cell is 5.7 times bigger than the 0.5 m cell, and will therefore provide a higher level of "comfort" in committing to a commercial installation.

A total of 113 tests were performed. In early testing, bitumen recoveries were very low. After exhaustively testing and pushing all available parameters over 24 tests, with no improvement in results, the mechanical configuration of the column cell was examined to identify any possible deficiencies. Because the column was to operate with relatively low feed flow rates, it was initially decided that an internal feed distribution system was not required. This proved to be the fatal flaw. An internal distributor comprising an elbow with a dispersion plate was quickly designed and installed, and results improved immediately. Results of the first 24 tests were eliminated.

Over the remaining tests, the mechanical scavenger circuit was systematically sampled in parallel with the column, to provide a more accurate basis for comparison. The column cell continued to out-perform the mechanical cells, as shown in Table 2.

Table 2 – Column vs. Mechanical

	Concentrate		Distribution	
	Assays		Bit	Min
	%Bit	%Min	Rec%	Rej%
Column	3.9	13.0	73.1	93.0
Mechanical	2.6	14.1	65.5	92.0

Note that Bitumen recovery in the 1.22 m column is consistent with recovery obtained in the 0.5 m column, but bitumen recovery in the mechanical circuit is somewhat improved over the previous period. The reason for this improvement is not known to the authors.

Parameter Effects

With the larger column and the higher number of tests, it was possible to evaluate in more detail some of the key operational parameters for column flotation. During testing, several test groups were dedicated to evaluating specific parameters.

Effect of Gas Rate: As with the 0.5 m column, gas rate seemed to have a very modest effect on bitumen recovery, improving recovery up to a gas rate of about 2.2 cm/s, with no benefit at higher gas rates. However, there was a well defined relationship between gas rate and mineral contamination of the concentrate, as shown in Figure 5.

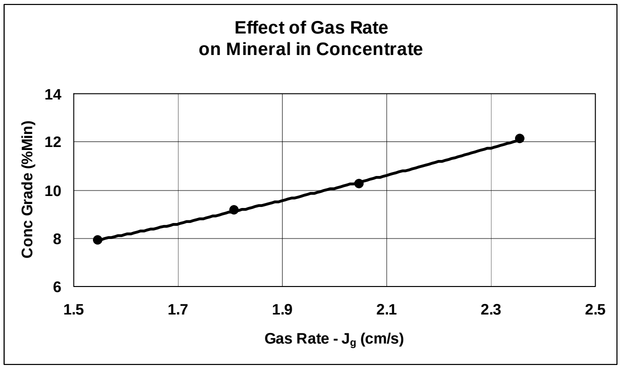

Figure 5 – Effect of Gas Rate on Mineral Grade

As expected, higher gas rates result in higher entrainment of mineral in the froth, and this is certainly consistent with widely known flotation concepts.

In general, the test results argue in favor of a gas rate of about 2.0 to 2.2 cm/s, which is consistent with 0.5 m cell testing.

Effect of Wash Water Rate: The function of wash water is to wash entrained mineral from the froth. In the case of bitumen recovery it must be remembered that all products are analyzed for bitumen, mineral and water, and water is considered to be a contaminant, not just a carrier.

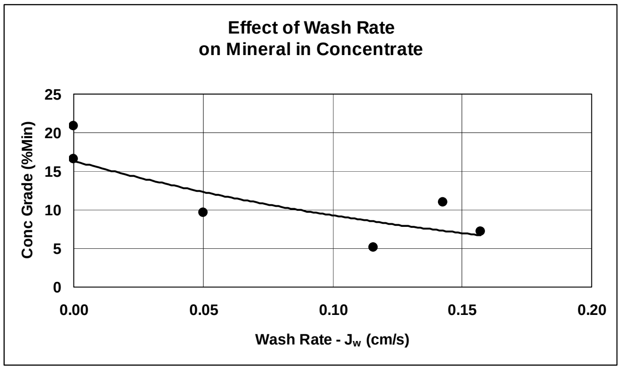

Figure 6 – Effect of Wash Rate on Mineral Grade

This data clearly indicates that wash water washes mineral from the froth. This is the expected effect and is consistent with the effect of column wash water observed over a wide range of applications.

Table 2 above confirms that column flotation improves bitumen recovery, thus satisfying the major objective of the test program. The above results also indicate that column flotation improves mineral rejection. This feature has significant implications in regard to controlling and optimizing Sep Cell throughput.

Separation Efficiency Curve: With extensive parallel sampling of the mechanical circuit it is now possible to show performance of both circuits on one graph, as illustrated in Figure 7. The similarity in plots indicates that the separation efficiency concept provides a workable vehicle for examining and comparing performance characteristics. The column appears to have performed slightly better than the mechanical circuit, but a closer examination of the high recovery region provides a better insight to the improvement. In Figure 9 it can now be seen that for a mineral rejection of 98%, the column achieved 10% better bitumen recovery over the test period.

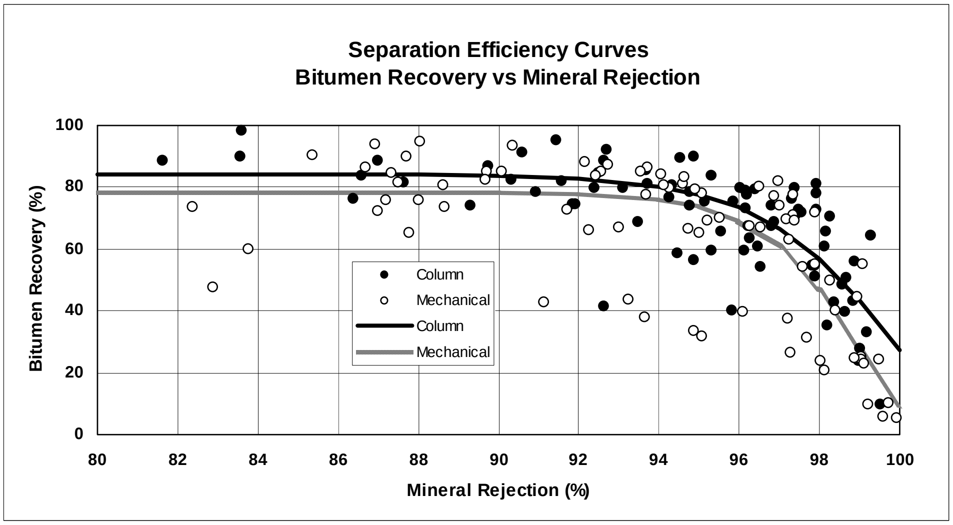

Figure 7 – Separation Efficiency Curves

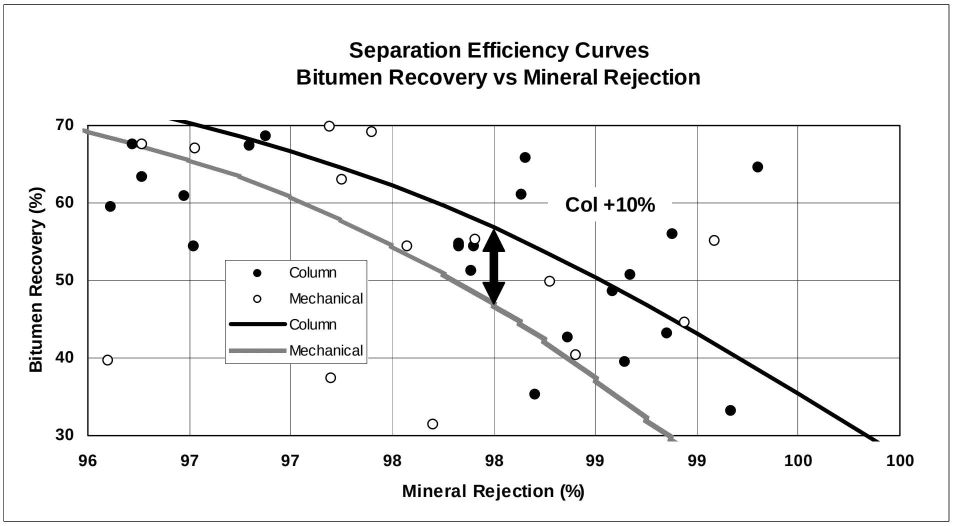

Figure 8 – Separation Efficiency Curves – Closer View

Comparing Test Columns

At the conclusion of testing in the 0.5 m column, although results were very good, there was some skepticism that the results from such a relatively small (compared to typical oil sands equipment) test unit could be used to reliably scale up to a full size commercial installation. These concerns were quite reasonable. It is well known that very small diameter test columns – 75, 100 and 150 mm diameter for example – operate in close to "plug flow" conditions, with little vertical mixing and almost no lateral mixing. The small diameter also serves to constrain and stabilize the froth bed, allowing better performance. Scaling up from very small diameter test columns involves some risk and should only be done with an extensive background knowledge and experience are available, and then with caution.

The larger 1.22 m cell is well beyond the plug-flow regime, and testing in this unit significantly eased scale-up concerns. With data from both cells now available, it is possible to compare performance characteristics.

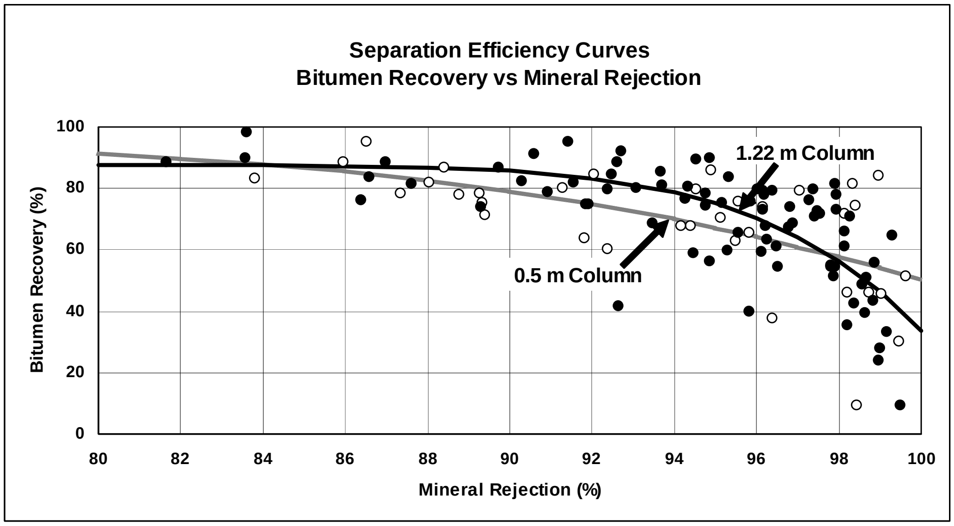

Figure 9 – Separation Efficiency Curves – 0.5 & 1.22 m Columns

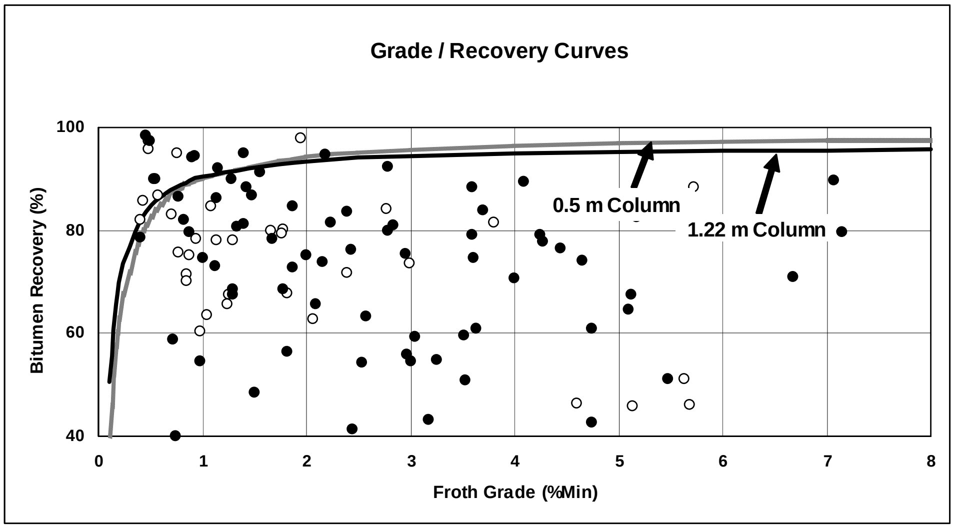

Figure 10 – Grade / Recovery Curves – 0.5 & 1.22 m Columns

Figure 9 shows that the larger 1.22 m column performed somewhat better than the smaller 0.5 m column. The separation curves, however, are remarkably similar.

In Figure 10 it can be seen first that the normal grade versus recovery curves don’t really exist. The curves shown were regressed using a modified exponential of the form y = a * exp (b / x), which seems to best represent the “edge” of the performance envelope.

Comparing Columns to Mechanical Cells

Performance: In laboratory testing it is always possible to evaluate parameters or variables one at a time, keeping all other variables constant. In plant testing, using real time plant products as feed stocks and with test periods covering weeks or months, it is inevitable that there will be scatter in the data.

In an attempt to compensate for this unavoidable fact, a “stability” test was performed. In this test all controllable variables and parameters were held as constant as possible, and the 1.22 m column and mechanical scavengers were sampled every hour over a nine hour period – total of ten hourly samples. The purpose of this test was, in part, to evaluate the variability of the only uncontrollable variable – the feed. The test would also be used to compare the column to the mechanical cells.

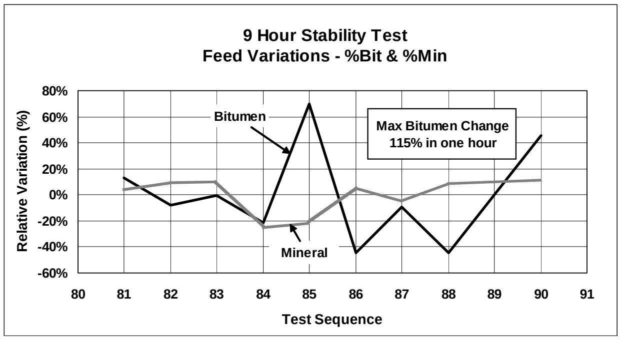

Figure 11 – Stability Test – Variations

While mineral content varied by about 30% (relative) over the 9 hour test period, the bitumen content varied by as much as 115% in just one hour.

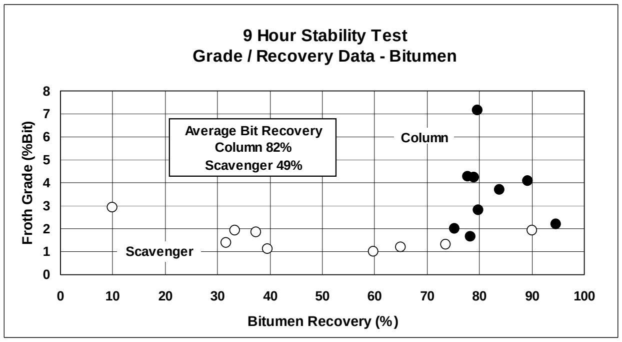

Figure 12 – Stability Test – Performance

The mechanical cells appeared to be relatively immune to feed changes in terms of froth grade (1% to 3% Bit) but bitumen recovery ranged from 10% to 90%. In the same period, and with the same feed variations, the column yielded a range of froth grades ranging from 2% to 7% Bit. The column, however, appeared to be capable of consistently maintaining much higher bitumen recovery. This data clearly shows the advantage of column flotation in improving bitumen recovery while maintaining good froth grade.

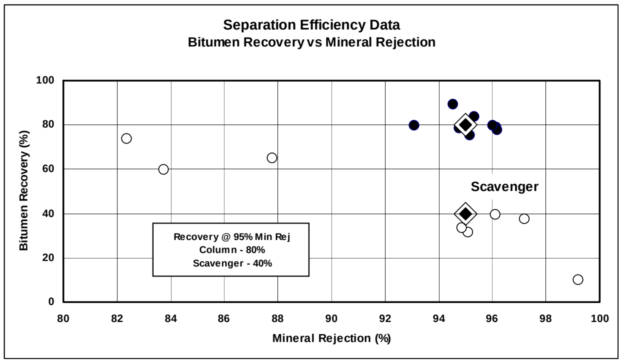

Figure 13 – Stability Test – Separation Efficiency

In Figure 13, the Stability Test results are plotted in the familiar Separation Efficiency format. This shows that, at a mineral rejection of 95%, bitumen recovery in the column (80%) was double the bitumen recovery in the mechanical cells (40%). The plot also shows that the column cell operated in a more stable fashion while the mechanical scavengers produced a wide range of mineral rejection values.

Operating and Maintenance Costs: The most significant maintenance issue with mechanical flotation cells is abrasive wear. The sand in oil sands is very abrasive. The story goes that each day at Suncor they wear away enough steel to make three or four Volkswagens. The mechanical cell rotors are a very high maintenance item in this aggressively abrasive environment. In addition, maintenance on the rotors requires taking the entire bank of mechanical cells off line, during which period the incremental bitumen recovery is permanently lost.

By comparison, column cells have no moving parts and – importantly – column cell maintenance can be performed without taking the cells off line. The only internal wear item is SlamJet sparger nozzles, and SlamJets can be removed on-line by means of an insertion port assembly. SlamJet ceramic wear-protected nozzles typically last one to two years. Externally, column cell underflow pinch valves require periodic valve sleeve replacements.

There are typically some modest power savings to be had with columns. There is an energy cost in generating small bubbles. In mechanical cells which are either self-aspirated or use low pressure blower air, the required energy is imparted via the rotors, which are subject to high wear. Columns have no rotors but require high pressure air, and the required energy is thus consumed in compressors, which typically have much lower maintenance costs.

CONCLUSIONS

Column flotation has been shown to offer significant improvements over conventional mechanically agitated flotation cells in secondary bitumen recovery.

Bitumen Recovery: Column flotation recoveries were 10% to 40% higher than parallel mechanical cells.

Mineral Rejection: Column flotation consistently matched or exceeded the capabilities of mechanical cells in mineral rejection while maintaining significantly higher bitumen recoveries.

Operating Costs: Column flotation requires compressed air but does not require power for a rotating agitator. Energy costs for column operation are typically less than for mechanical cells.

Maintenance Costs: With no moving parts and with the ability to extract the only wear part (SlamJet sparger nozzles) without shutting down column operation, column flotation offers significantly lower maintenance costs.

This test program also confirmed that results obtained in a relatively small 0.5 m diameter pilot column compare very well with results obtained in a medium size 1.2 m diameter column. The “Separation Efficiency” curve was shown to be a useful tool in examining bitumen flotation.

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