USE OF THE INLINE PRESSURE JIG IN DIAMOND APPLICATIONS- WITH PARTICULAR REFERENCE TO AFRICAN INSTALLATIONS.

DH Davidson
Namdeb Diamond Corporation

PM Grady
Gekko Systems (Canada)

RA Heins
Gekko Systems (SA)

ABSTRACT:

The applicability of jig technology to the recovery of diamonds in kimberlite and alluvial deposits has long been known and accepted
The current drive to maximize the recovery from resources has triggered a resurgence of interest in the retreatment of tailings deposits. Due to the typically very low grades of these resources, innovative thinking is required in order to treat them profitably.

The De Beers Group saw this opportunity about 4 years ago at the Williamson Mine in Tanzania and installed 6 InLine Pressure Jigs, supplied by Gekko Systems, as pre-concentrators ahead of a conventional Dense Media Separation plant.

Installation and operational issues militated against the success of this plant until late 2004 when a joint De Beers/Williamson/Gekko initiative was launched to rectify the installation and resolve the issues.

Process control instrumentation was retrofitted to one IPJ and a battery of recovery tests were performed, yielding 100% recovery of simulants and tracers. Partition curves were plotted and an operating regime for continuous operation was recommended based on the excellent results obtained.

Simultaneously, Namdeb have adopted IPJ technology for the purpose of shell removal in marine/alluvial gravels on the Floating Treatment Plant and for the Pocket Beaches mobile plant. and to explore the possibility of preconcentration of all diamondiferous materials on the West Coast.

Operating data and test results are presented from both the Williamson tests and the Namdeb operations.

Keywords: Diamonds, tailings, gravity concentration

INTRODUCTION

History and Background to the IPJ

The InLine Pressure Jig (IPJ) was developed by Sandy Gray in the early 1990's to make his life easier and his recoveries better as gold prices slipped while running an alluvial gold operation in South Australia.
Following the successful invention and development, the product was commercialized and formed the basis for the foundation of Ground Developments (later to become Gekko Systems) in the mid 1990's.

The first commercial installations were in alluvial gold in the mid 90's, and in 1996 the value of the unit for gravity concentration in the circulating load of a hard rock gold mill was realized. This was followed by a number of smaller applications over the next few years, with installations into silver, garnet and kaolinite to name a few, however the next major break came in 1998-99 when Gekko Systems were approached by De Beers of South Africa to test the IPJ applicability to diamond recovery.

De Beers carried out Testwork on a number of applications, both alone and in conjunction with Gekko Systems, leading to plant scale installations from 2002 onwards in marine and kimberlite tailings diamond recovery operations.

The InLine Pressure Jig (IPJ) is an effective and efficient gravity separation device that has found application in the processing of a wide variety of minerals. While based on the same principles as traditional jigs, its pressurised design and advanced control system give it many advantages including high recovery, high unit throughput, and low water consumption, close control of operating conditions, low installation cost, low operating costs and high security. The IPJ can be used either in placer deposits as the primary concentrator or in hard rock circuits to treat all or part of the cyclone underflow or mill discharge. As a result of the large range of jig parameters and ragging types possible, the IPJ has successfully been used for a range of minerals, including gold, sulphides, silver, native copper, tantalum, garnet and diamonds.

The IPJ is a compact, low cost continuous process that requires minimal infrastructure or logistical support. In addition to its low capital cost, it has very low operating costs per volume treated, and very low power requirements. Hutch water can be supplied from the ocean; rivers, boreholes, thickener overflow or slimes dam return. Trials using de-sliming cyclone overflow as hutch water have been conducted without any noticeable adverse effect on jig performance up to 5-6% solids w/w. The IPJ consumes as little as 10% of the water required by traditional jigs, which has obvious advantages in the arid regions of the world where much of the mineral exploitation takes place.
There are currently over 100 IPJ's in operation around the World, many in Africa treating a variety of minerals, including 21 currently used in diamond applications.

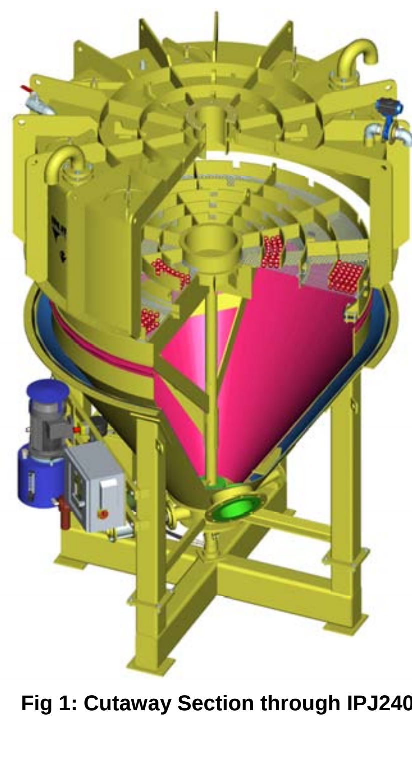

Fig 1: Cutaway Section through IPJ2400

Theory of Operation

The IPJ is unique in its design and use of jigging concepts. The unit is fully encapsulated and pressurised, and combines a circular bed with a moveable sieve action. The encapsulation allows the IPJ to be completely filled with slurry and water. As a result, slurry velocity is slowed and water surface tension eliminated improving recovery potential, particularly in gold applications. The screen is pulsed vertically by a hydraulically driven shaft. Length of stroke and speed of up and down stroke can be varied to suit the application. Screen aperture, ragging dimension and ragging material can also be altered for the application.

Separation of values from gangue particles occurs based on relative density as well as particle size and shape

According to Aplan [1], the ease of separation of a pair of minerals from one another based on their density differences can be estimated using the concentration coefficient. This is defined as:

$$\text{Concentration coefficient (cc)} = \frac{\rho_H - \rho_M}{\rho_L - \rho_M}$$

Where ρ_H is the specific gravity of the dense or heavy component, ρ_M is the specific gravity of the fluid medium in which the mineral mix is suspended, and ρ_L is the specific gravity of the light component.

For the case of diamonds, ρ_H is 3.55, ρ_L is 2.4-2.7 dependant on the application, and ρ_M is 1.0 for a water medium.

Thus for an oxidised kimberlite tailings dump with a gangue specific gravity of 2.4, concentration coefficient becomes 1.82.

The ease of separation denoted by this value is also extremely sensitive to the size range of the materials to be separated. For example, the separation is much easier and can be performed to much finer sizes for a gold application with a concentration coefficient of around 11, than is practical for a diamond application with a cc of around 2.

Separation at low concentration coefficient values has historically been a weakness for jigging and ultimately led to the replacement of jigging by dense media technology in the diamond recovery industry resulting from inaccurate cut points or low recoveries. However, the development of spherical synthetic ragging has improved the performance of the IPJ in applications where the concentration criteria is below the accepted norm for jig application

The performance of a specific gravity concentration device is measured using a Tromp or Partition curve.
This partition curve illustrates the percentage of product reporting to sinks at different particle densities.
The practical application of this involves the feeding of a known quantity of particles of known size, shape and a range of densities, and measuring the recovery of these particles to floats and sinks products.

A typical partition curve is illustrated in Fig 2, it is obvious that for a perfect split at a given density the cut point line should be vertical, however, production processes are not ideal and as such a measure of this imperfection is given by the EPM or E_p (*ecart probable moyen*).

The EPM is defined as half of the specific gravity difference between the 25% and 75% cut points on the partition curve, hence the lower the EPM value obtained, the closer to vertical the separation line and hence the more accurate the density cut.

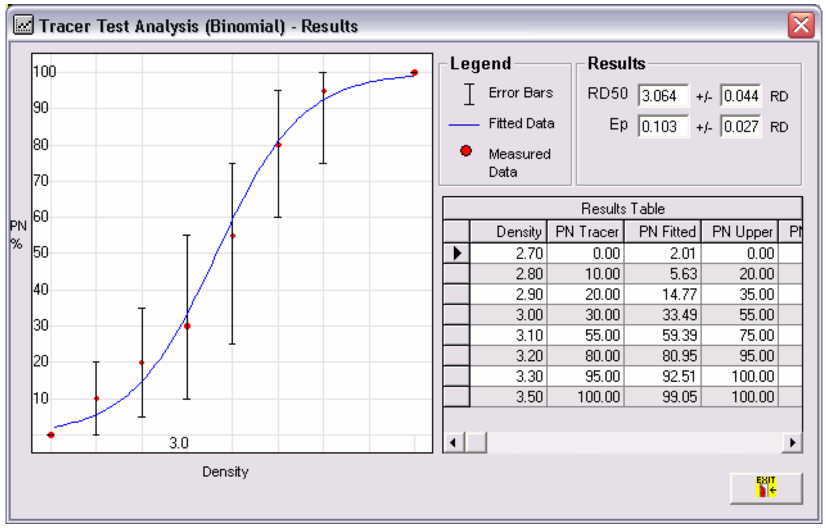

Fig 2: Typical partition curve for density tracer results

The use of synthetic ragging has also improved the EPM values which can be achieved by the InLine Pressure Jig, leading to much more efficient operation in terms of both mass yield to sinks and also efficiency of diamond recovery to sinks.

The IPJ operates by drawing the higher specific gravity particles into the concentrate hutch during the suction stroke of the bed, the ragging, and being of a density intermediate to the sinks and floats components settles after the heavy component and effectively locks the concentrate hutch closed behind the heavies which are continuously discharged. The lighter gangue is discharged over the tailboard to the outer cone. Both concentrates and tailings are discharged under pressure.

The separation of the fractions occurs via a combination of hindered settling, sedimentation and elutriation in the freeboard above the jig bed and via hindered settling once the particles engage in the bed. [2]

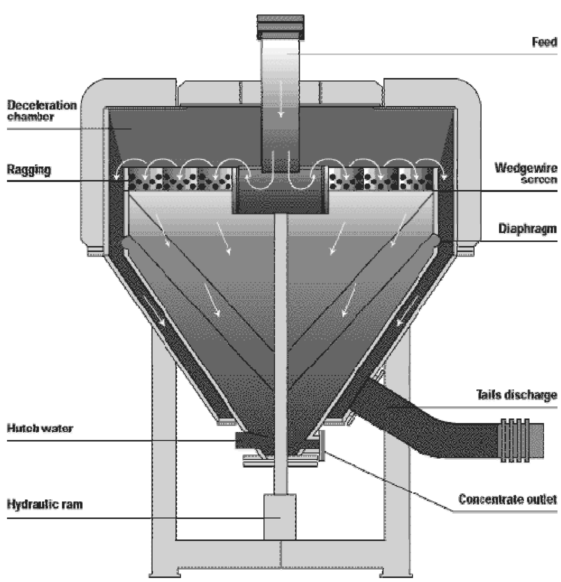

Fig 3: Section through IPJ showing mechanism of operation

Applicability and Benefits of the IPJ in Diamond Pre concentration

The IPJ can be applied to diamond recovery wherever there is a low density, low value bulk in the orebody to be treated, such as shell in marine diamond gravels, clay in alluvial diamond gravels, or oxidized kimberlite/lamproite in tailings dumps. Effectively, the IPJ reduces operating costs by increasing the plant throughput without the need to increase dense media plant capacity. This is of particular value in low-grade deposits where maximum throughput is critical to achieve the recovery of reasonable values, and hence sustainable cashflows.

The IPJ also has the potential to reduce operating costs still further by reducing the load on downstream processes such as dense media and X-ray sorting with their relatively high costs of operation.

This was highlighted during 2004, when the Kimberley Diamond Company [3] issued their operating results after commissioning of the new East Plant, which comprised a 300 t/hr DMS plant with no preconcentration compared with the existing West Plant comprising a 100t/hr IPJ pre-concentrating ahead of a DMS plant. The quarterly results indicate that treating the same material a saving of AUD$1.00 per ton treated (30% of the processing cost) was realized using pre-concentration with IPJ technology.

CASE STUDY 1: WILLIAMSON DIAMONDS LTD - TANZANIA

In June of 2001, De Beers approached Gekko Systems to provide an InLine pressure Jig for application testing on feed originating from a significant dense media plant tails stockpile, which had been deposited over the years of operation at the Williamson Mine in Mwadui, Tanzania.

It was felt that this resource was likely to provide significant value to the Williamson operation, and could offset the falling revenues being experienced due to declining grades in the main Williamson kimberlite pipe.

Test work was performed for a Kimberlitic tailings project. An IPJ1500 was fed from a small hopper and pump, with the tails and concentrates reporting to dewatering screens. The concentrates were collected into a ‘skip’ and hand-sorted to recover the tracer beads.

The feed material was a screened -25mm DMS tailing product.

Table 1: Williamson Testwork Results

% Recovery	Test number					
	1	**2**	**3**	**4**	**5**	**6**
4 mm tracer	93	85	78	73	98	95
6 mm Simulant	100	100	95	91	100	97
8 mm Simulant	100	100	100	98	100	100
12 mm Simulant	100	100	100	100	100	100
16 mm Simulant	100	100	*	*	100	100
20 mm Simulant	100	100	*	*	100	100

The results of the initial testwork are presented in Table 1. It may be seen from Test 5 that at a sinks yield of 15%, over 99.6% recovery of diamond tracers could be achieved. It became apparent that the InLine Pressure Jig could provide an economic means of pre concentrating the dms tailings allowing a small new dms plant to be purchased to treat the jig concentrates, thus significantly reducing the capital and operating cost implications of this retreatment application.

The decision was made and board approval granted in October 2001 for the installation of a full plant to treat 600 tons per hour of Jig feed, pre-screened at –25+1.5mm. The initial timeline was to fast track the project and the plant was started up in June 2002.

The main motivations for the plant included:

- Diminishing grade
- Increasing debt
- Expense of conventional plants
- Quick action required

Fig 4: Completed Williamson Tailings Plant

A number of criteria were used to motivate the project including; tonnage throughput, diamond grade in the dump, diamond value and plant operating cost. [4]

Capital availability was however a constraint given the declining revenues being experienced, as a result, the plant was not instrumented or automated as per supplier's recommendations. The schematic diagram for the instrumentation as installed is presented as Figure 5.

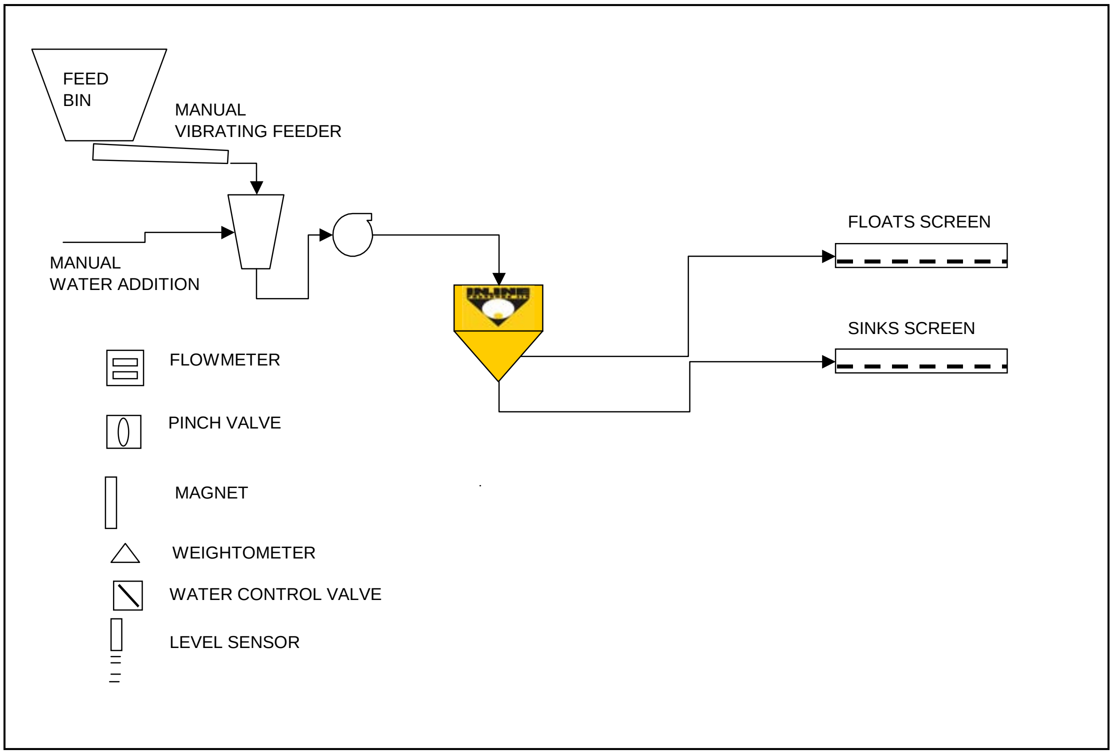

Fig 5: Automation schematic for IPJ plant as installed

It became apparent post commissioning that there were a number of issues with the project as a whole. These manifested themselves as low throughput tonnages, low diamond values, low recovery grades from the tailings dump and high operating costs. [5]
It was not apparent whether the low recovered grades were due to losses in the process or low grades from the dump, the lack of instrumentation installed meant that this could not be established categorically, in spite of numerous site trials and test programmes. These problems ultimately led to the plant being modified to run the dense media section on sorthouse tails, while the IPJ's sat idle

During the course of 2004, it was decided to finally establish the applicability of InLine Pressure Jig technology to specifically the Williamson tailings deposit, and as such a joint 'task team' was formed comprising representation from Gekko Systems, De Beers Group Technical Services, Williamson Diamonds and Namdeb Diamond Corporation.

Goals of the project:

A series of goals were set for this project:

- Does the IPJ work in the Williamson tailings application and what diamond recoveries can be expected?
- What are the effects of changing operating parameters on the diamond recovery performance of the IPJ?
- What are the optimum operational settings for the IPJ in this application for continuous operation, and what results can be expected?

Project Methodology:

A project timeline was developed with a start date of November 2004, due for completion in June 2005; the project commenced with a Gekko visit to site to agree the scope and details of the project, a summary of the steps following this is presented as follows:

1. Gekko to design optimum automation/instrumentation package and layout for a single IPJ installation
2. WDL to purchase the necessary instrumentation
3. Gekko to travel to site to do the equipment installation
4. Gekko/Namdeb/WDL/GTS commission and do tracer tests at various operating conditions to establish effect on partition curves and recovery at different operational settings

1. Instrumentation Design:

The redesigned instrumentation and automation package is presented as Figure 6.

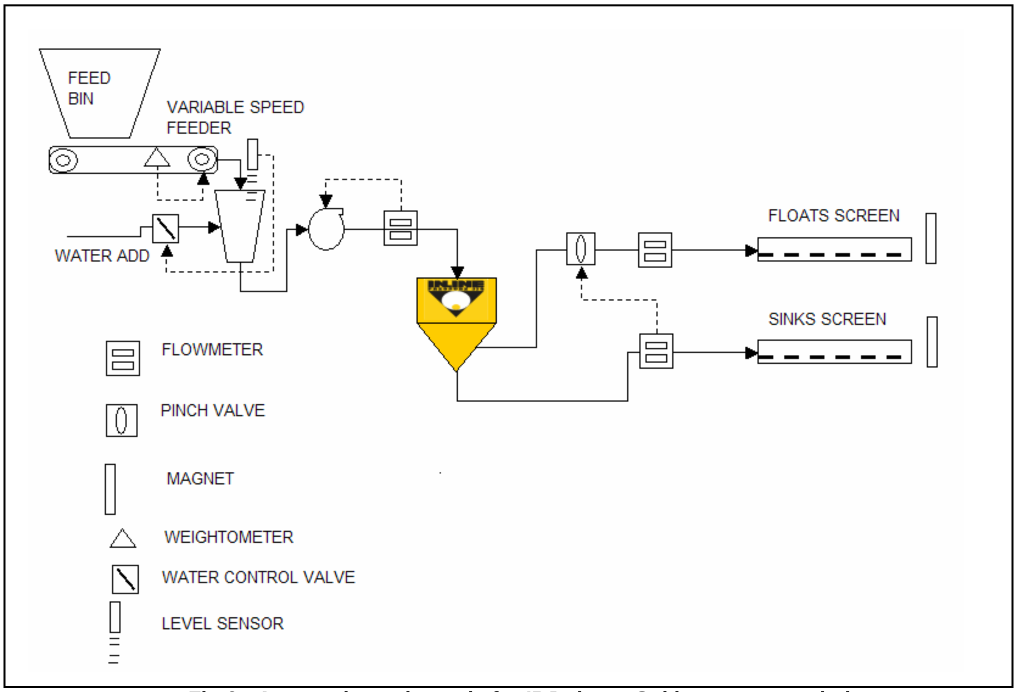

Fig 6: Automation schematic for IPJ plant - Gekko recommendation

2. TESTWORK (All test data after Grady – 2005[6])

As a precursor to the trial, a batch of low-grade kimberlite dense media plant tailing material was reclaimed from the tailings dump and stockpiled at the Multi Purpose Plant where it was to be treated.

The material was fed through the plant, where it was screened into the size range +1mm- 25mm and then stored in a feed bin ahead of the IPJ and dms circuits.

The feed to the IPJ consisted of stockpiled material with an average D_{50} value of approximately 6 mm. A total of 1 874 wet tons of material was treated though the IPJ as part of the batch tests.

Average size distribution for the feed material is illustrated in Figure 7.

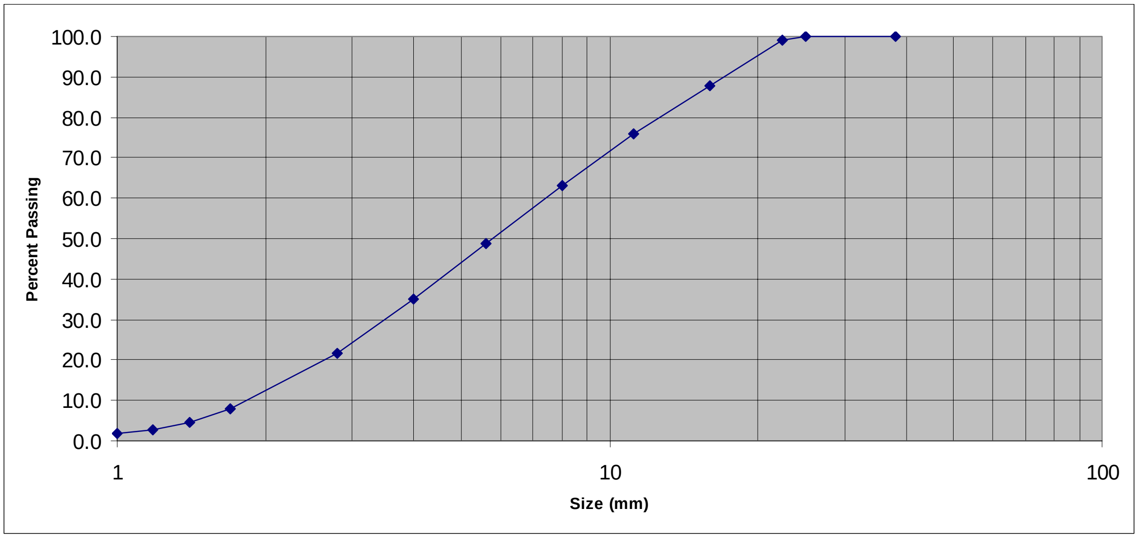

Figure 7: Average Feed Size Distribution for Batch Scale Test Work

A series of 40 batch scale tracer tests were conducted to optimize the performance of the IPJ2400 according to the following procedure:

-A known quantity and density distribution of magnetic density tracers was added to the IPJ feed after a predetermined period once the circuit had reached steady state conditions.

-These tracers were recovered on the magnets suspended above the floats and sinks screens, and the density distribution reporting to each product stream was plotted for each size of tracer under different operating parameters.

-The distributions were plotted as partition curves from which the EPM values were derived using the JK Mineral Research Centre modeling software [7]

The partition curves generated for all tests are not included as part of this paper, but are available from the authors direct or from Gekko Systems.

The IPJ is characterized by having a wide range of operating variables available for manipulation, such as: ragging volume, ragging size, ragging density, hutch water feed rate, pulse rate, stroke length, and downstroke rate. As part of the test program, ragging volume, hutch water rate, pulse rate, and stroke length were each investigated.

The results from each of these parameter tests are presented individually in the sections that follow.

TEST 1: EFFECT OF RAGGING DEPTH

The mechanism by which ragging operates is discussed previously.
The addition of more ragging into the IPJ increases the density cutpoint and hence the IPJ recovery efficiency changes.
A number of trials at different ragging depths were performed to quantify this effect. Ragging specific gravity and size also affect performance; however they are not investigated here.

Fig 8: Synthetic 3.2 sg ragging on IPJ Hutch screen

Table 2 shows the effect on 3.5 sg tracer recovery when reducing the ragging volume at a constant feed rate of 73 tph. As ragging volume is reduced from 250% to 159%, recovery in the 8 mm and 4 mm size fractions is increased. (Note that % ragging profile is defined based on 100% being sufficient ragging to cover the entire screen surface to a monolayer)

Table 2: Effect of Ragging Profile on 3.5 sg Tracer Recovery

Test	Ragging Profile	12 mm Recovery	8 mm Recovery	4 mm Recovery
9	250%	100%	80%	81%
13	200%	100%	95%	86%
14	159%	100%	100%	98%

Figure 9 illustrates the partition curves for ragging profiles of 159% and 146% at constant feed rate of 86 tph. By reducing the ragging volume, D_{50} decreased from 2.808 to 2.084, while EPM increased from 0.201 to 0.263.

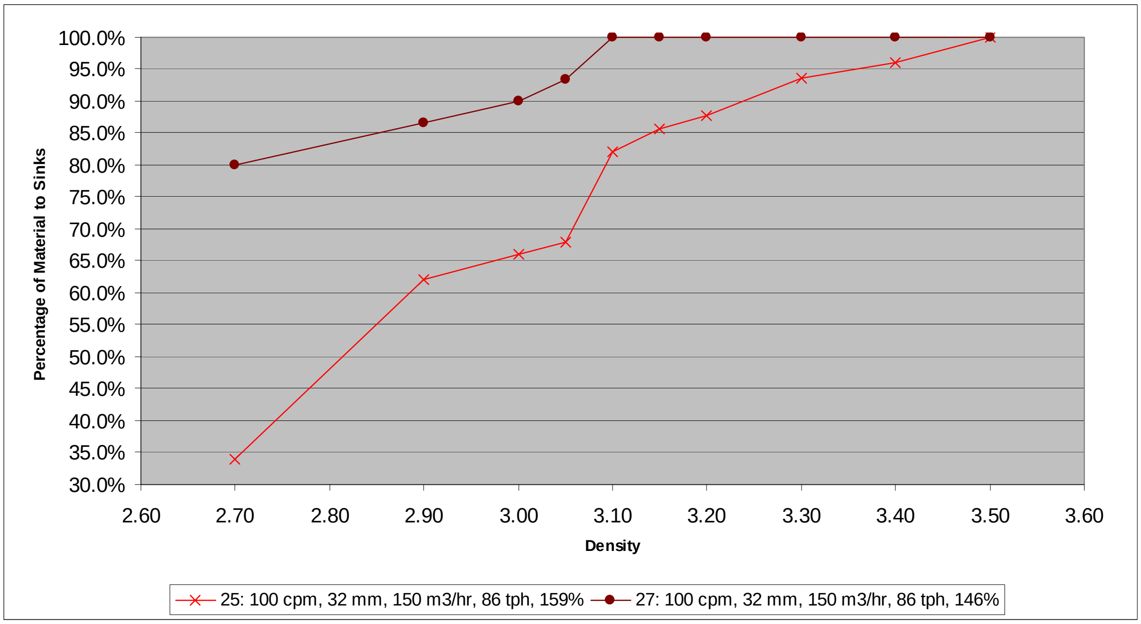

Fig 9: Partition Curves for Ragging Profiles of 146% and 159% for 8 mm Tracers

As the test program progressed, ragging was gradually removed until the appropriate trade-off between recovery and efficiency was met. Minimum volume of ragging tested was 120%, which proved to be insufficient as the increased interstitial spacing resulted in approximately 90% of feed reporting to concentrate, which although giving very high IPJ efficiency in terms of diamond recovery, meant that there was almost no benefit in terms of pre concentration. This configuration would have been more suitable to higher feed rates; however the interaction effect between these two variables was not investigated. This area requires additional work to quantify the interaction.

After ragging volume was increased to 147%, control of the IPJ was regained. IPJ parameters such as stroke length and pulse rate could then be used to further optimize IPJ performance.

The ideal ragging depth for the Williamson tailings application at a feedrate of 70-80 tons/hr is 147%.

This ragging depth may require periodic adjustments, to maintain constant IPJ efficiency when operating at different feed densities. However, periodic changes to the ragging depth are impractical and the IPJ must rather be optimized for average feed conditions. Continuous test work will determine the required operating parameters for alternative feed scenarios.

TEST 2: EFFECT OF MASS FEED RATE

The mass feed to the IPJ is a critical operating variable, as this, in conjunction with the volumetric feed rate determines the residence time of a given particle in the IPJ, and hence the amount of time it has available to report to the correct product stream dependant on its density.

As a result, the recovery of different densities of magnetic tracers to the two product streams was investigated for different solids feed rates, (it should be noted that the volumetric feed rate to the IPJ remained constant for these tests, meaning that this test also measured the effect of varying the liquid/solids ratio of the feed on IPJ operation).

Solids feed rates for the test work ranged between 47 and 87 dry tons per hour.

Table 3: Effect of Mass Feed Rate on 3.5 sg Tracer Recovery

Test	Mass Feed Rate Wet tph	12 mm Recovery	8 mm Recovery	4 mm Recovery
27	86	50%	90%	92%
28	92	100%	100%	90%
29	105	60%	100%	84%

Table 3 shows the effect on 3.5 sg tracer recovery of increasing the wet solids feed rate from 86 tph to 105 tph (equating to 73 to 90 dry tph solids). The results obtained for the 12 mm tracers is felt to be spurious and a result of tracers 'hanging up ' inside the IPJ, this is substantiated by the recovery trend of the 8mm tracers which would be more difficult to recover than the 12mm particles. The effect on the 4mm tracers however is significant with the recovery dropping steadily as tonnage throughput is increased and hence residence time is reduced. As feed rate is increased, both separation efficiency and recoveries to sinks in the -3.40 sg fractions decrease as shown in Figure 10.

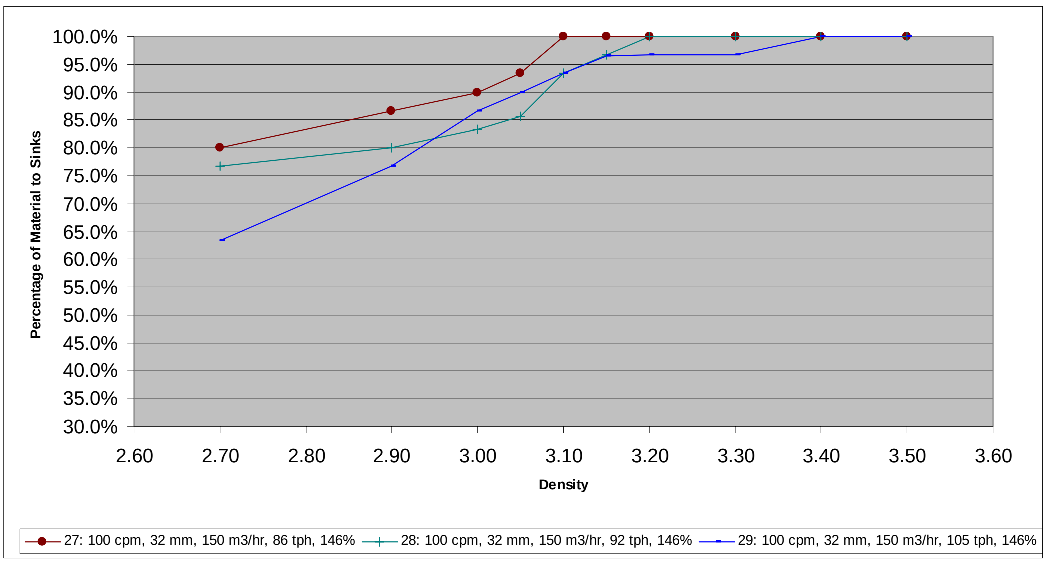

Figure 10: Partition Curves for 8 mm Tracers at Varying Solids Feed Rates

A solids feed rate of 85 wet tons per hour is recommended for the tailings application at a ragging depth of 147%. This equates to a dry feed rate of approximately 73 tons per hour

It may be seen from the partition curve that the effect on lower sg particle recovery is significant once the dry solids feed rate increases above 85 tons per hour, which should be regarded as a notional maximum feed tonnage to the IPJ for this application.

TEST 3: EFFECT OF VOLUMETRIC FEEDRATE

The reduction in volumetric feed rate (at constant mass feed rate) leads to the minimizing of make-up water requirements, thus providing relief for the plant water balance. As volumetric feed rate is reduced, both average retention time inside the jig and slurry density is increased. The effect on retention time inside the IPJ is presented in Figure 11.

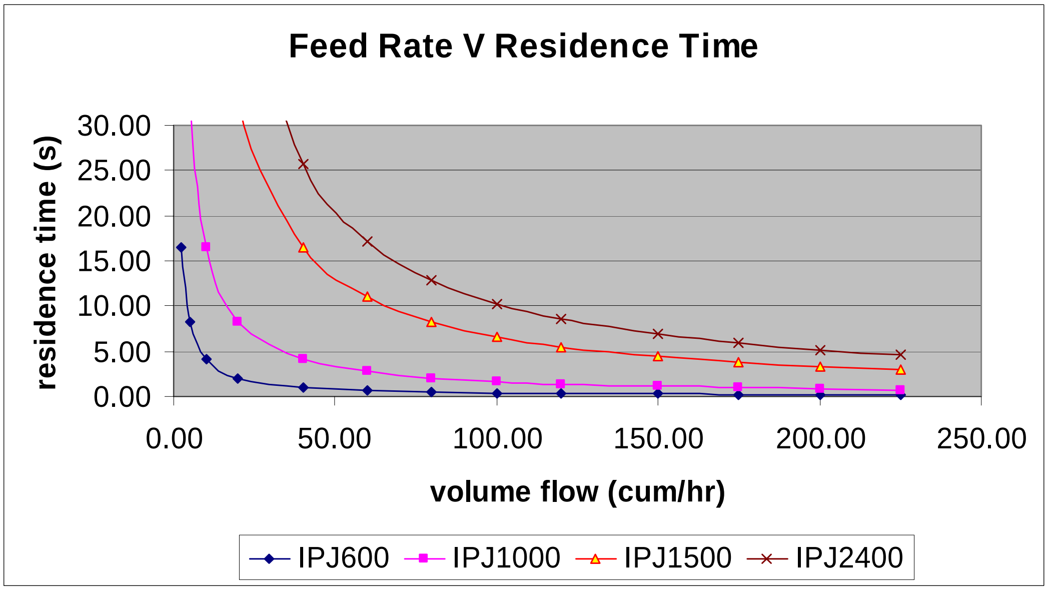

Fig 11: Effect of Volumetric feed rate on IPJ residence time

At a volumetric feed rate of 150 m^3/hr the average retention time inside the jig is 7 seconds, compared to 9 seconds at 120 m^3/hr

The effect on recovery of the range of density tracers was tested at volumetric feed rates of 150 m^3/hr, 130 m^3/hr, and 120 m^3/hr.

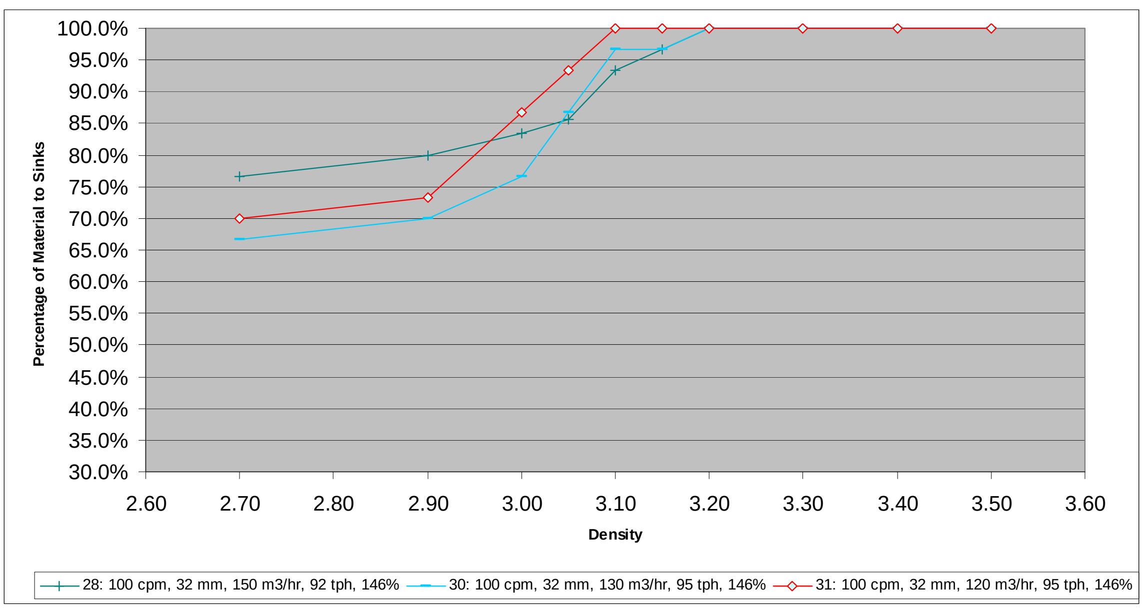

Figure 12: Partition Curves for Volumetric Flow Rates of 150, 130, & 120 m^3/hr

From Figure 12, it may be seen that both efficiency and recovery are improved by reducing the volumetric feed rate, with little or no effect on the 8mm tracers with sg greater than 3.20.

The reduction in volumetric feed rate from 150m^3/hr to 120m^3/hr saw the D_{50} for the separation increase from 2.20 to 2.56 and the EPM reduce from 0.302 to 0.156

Although the best results were obtained at a volumetric feed rate of 120 m^3/hr, pumping limitations (low settling velocities) made it impractical to operate in this range.

As a result of these tests, a volumetric flow rate of 130 m^3/hr is recommended for the Williamson application.

TEST 4: EFFECT OF STROKE LENGTH

The dilation of the bed, through which all particles reporting to concentrate must pass, is determined in part by the hutch water upflow, but mainly by the length of the stroke of the jig pulse.

This is controlled hydraulically, but is constrained by the volume of hydraulic fluid, which the pump can deliver within the cycle time setpoint, as a result of the effect of bed dilation, the recovery and partition is also directly affected by stroke length. This effect was investigated.

During the initial 8 trials (tests 3 through 10), stroke length was limited to a maximum of 25 mm at a pulse rate of 80 cycles per minute. Results from these initial tests showed that longer stroke lengths would be required to ensure adequate bed dilation and maximum recoveries.

After test 10, mechanical changes were made to allow for a longer stroke length, increasing the maximum from 25mm to 35mm.

Table 4 illustrates the effect on 3.5 sg tracer recovery to concentrate of increasing the IPJ stroke length.

Table 4: Effect of Stroke on 3.5 sg Tracer Recovery

Test	Stroke Length (mm)	12 mm Recovery	8 mm Recovery	4 mm Recovery
8	21	100%	83%	76%
12	23	100%	84%	86%
18	25	100%	100%	93%
21	30	100%	100%	100%
23	33	100%	100%	100%

It may be seen that the longer stroke length has a strong effect on the dense tracer recoveries, particularly at the lower stroke lengths, which result from high pulse rates. This is confirmed by the upper end of the partition curve presented in Figure 13. The improved recoveries of the 4mm tracers at longer stroke lengths can be attributed to increased bed voidage, which allows for increased mass pull to concentrate.

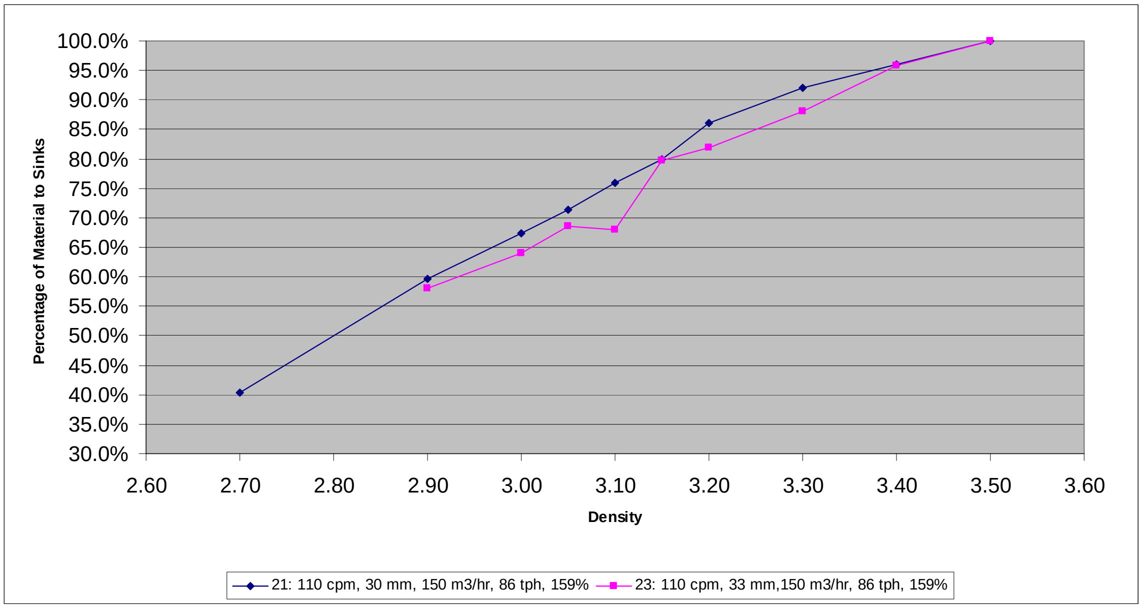

Figure 13: Partition Curves for Stroke Lengths of 30 mm and 33 mm for 8 mm Tracers

Gekko recommends a stroke length of 32 mm for the continuous test program. Stroke length should not exceed 32 mm, as the rubber diaphragm could be potentially compromised and the recovery also drops.

TEST 5: EFFECT OF PULSE RATE

The pulse rate (cycles per minute) of the IPJ was found to be another variable with strong influence over IPJ performance, and is directly related to the stroke length as the capacity to deliver sufficient hydraulic fluid to the ram is dictated by the length of time in which the pump has to deliver the fluid (the cycle time).

The pulse rate affects IPJ performance by increasing sorting opportunities within the IPJ (the number of opportunities a particle has to report to the correct product stream during its residence time within the process), which results in increased recovery and also increased separation efficiency.

Table 5: Effect of Stroke on 3.5 sg Tracer Recovery

Test	Pulse Rate (c/min)	12 mm Recovery	8 mm Recovery	4 mm Recovery
10	80	83%	88%	80%
18	110	100%	100%	91%
17	120	100%	100%	100%

Figure 14 highlights the effect of increasing pulse rate on partition. As pulse rate was increased from 100 to 105 cycles per minute, recoveries to sinks in the 3.15 to 3.40 density fractions were greatly improved with an increased mass yield to concentrate. Table 5 also indicates the general improvement in 3.5sg tracers with increasing pulse rate.

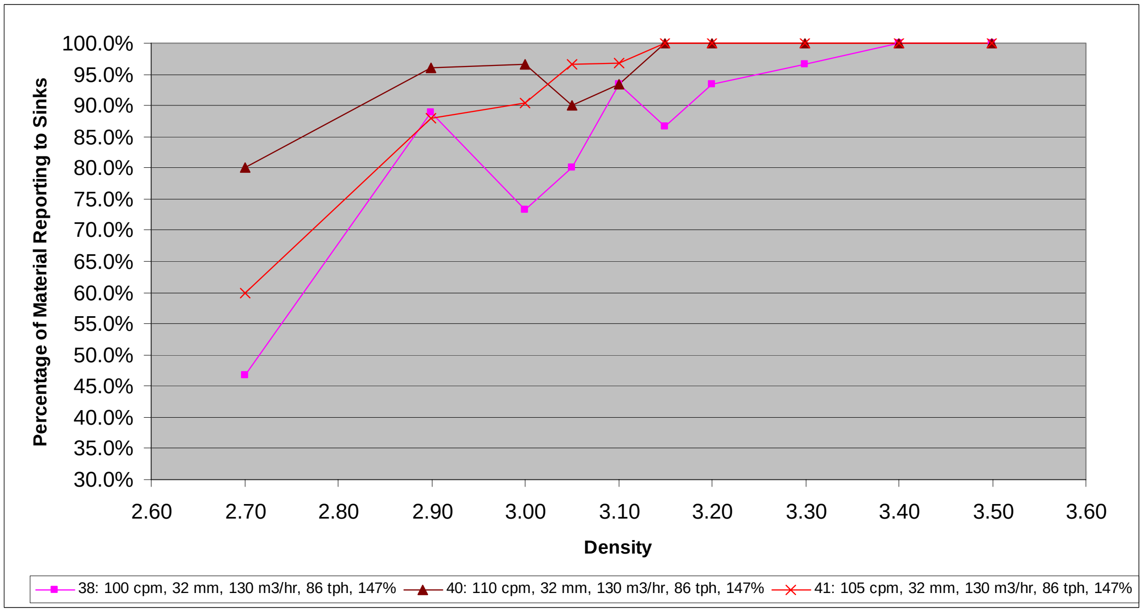

Figure 14: Partition Curves for Pulse Rates of 100, 105 and 110 cycles/min for 8mm Tracers

As a result of this test a pulse rate of 110 cycles per minute is recommended for the tailings application, this is the maximum attainable pulse rate while still maintaining the recommended 32mm stroke length.

Increasing pulse rate beyond this value will lead to shorter stroke lengths than recommended with consequent risk of value loss.

SUMMARY OF RESULTS:

40 tracer tests were performed using the IPJ to identify both the operating envelope for the five process variables examined, and also to assess the effect of operation outside this ideal envelope.

Figure 15 presents a scatter graph with the recovery of 4mm 3.5 sg tracers to concentrate at the mass yields obtained for all of the tests performed.

It may be seen that the mass yields are all clustered between 7 and 15%, which is significantly lower than was expected, but does leave DMS tonnage capacity available for further optimisation or should the density characteristics of the ore change, by increasing the mass pull to concentrate.

The 4mm recoveries obtained can be seen to be scattered between 75% and 100%, this is however due to the testing regime, whereby the IPJ was run outside the recommended operating envelope, with 100% recovery of all 3.5sg tracers (12,8 and 4mm) being obtained for the 12 tests performed at the optimum operating set-points.

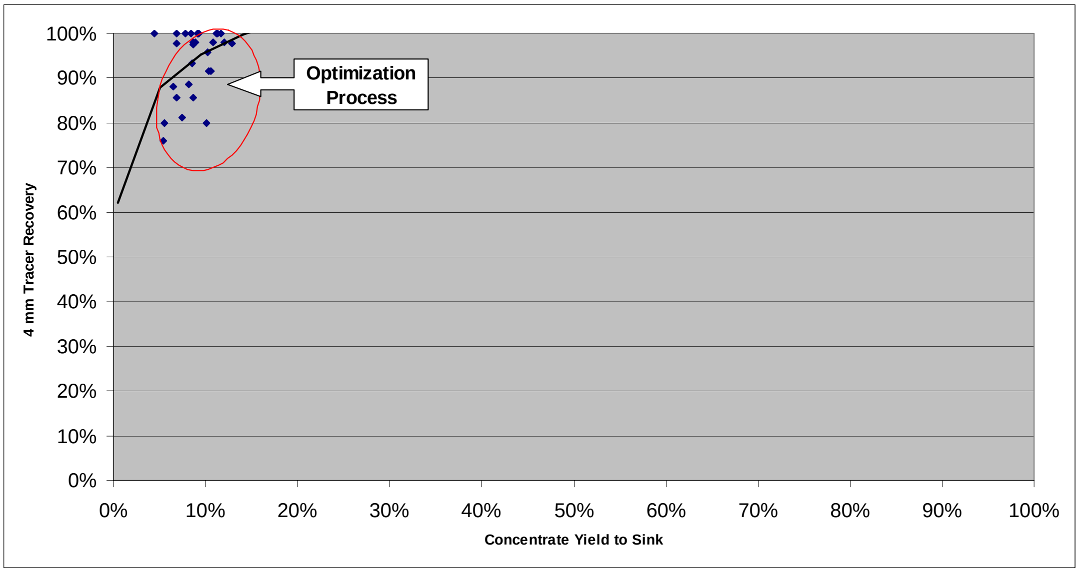

Figure 15: Summary Yield/Recovery Curve for tests performed

It is concluded from the test programme that the ideal operating conditions for the InLine Pressure Jig in the Williamson dms tailings application are as follows:

- Ragging Depth – 147%
- Solids Feed Rate – 70 to 75 dry tons per hour
- Volumetric Feed Rate – 130m^3 per hour
- Stroke Length – 32mm
- Pulse Rate - 110 cycles per minute

At these operating parameters, an IPJ density cutpoint of 2.4 may be expected with an EPM of 0.19 and a concentrate yield of 10-15% by mass, providing that the density characteristic of the feed material does not change significantly. 100% recovery of all 3.5 sg density tracers from 4mm up may also be expected under these operating conditions.

CASE STUDY 2: NAMDEB DIAMOND CORPORATION – NAMIBIA – IPJ INSTALLATION FOR SHELL & CLAY REMOVAL

2a) Floating Treatment Plant

During 2001 Namdeb approached Gekko Systems in South Africa about the use of the IPJ technology for the purpose of shell removal on the Floating Treatment Plant (FTP). The FTP treats about 8 million tons of overburden and marine gravels (see figure.16 for Size Frequency Distribution of head feed) per annum with a design feedrate of 2100tph. The original installation involved scalping, screening and sizing the material before being fed to a 200tph DMS plant. The material was sized to -25+2mm (45% gastropod shell, see Table 6 for shell Size Frequency Distribution) and fed to a DMS consisting of primary and re-concentration sections. Tests performed by De Beers Marine SA showed that conventional DMS removes a maximum of 40% of Gastropod shell (G-Shell) and 70% of bi-valve (flat and broken shell), this results in high percentages of shell material (misplaced floats) present in the final DMS concentrate.

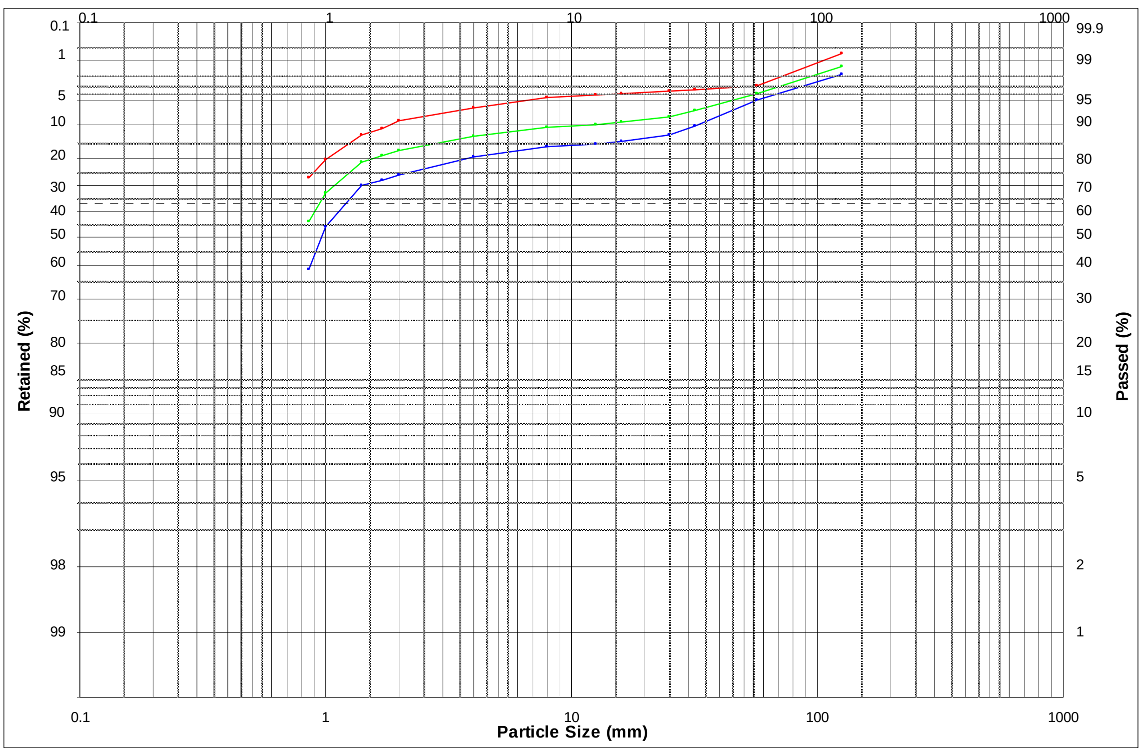

Figure 16: Size Frequency Distribution for DMS Head Feed

Table 6: Shell SFD for DMS feed.

DMS FEED SHELL COMPOSITION		
Size range	Lower envelope %	Upper envelope %
+ 25mm	**0.32**	**0.39**
- 25mm +19mm	**9.74**	**8.58**
- 19mm + 16mm	**22.83**	**11.95**
- 16mm + 8mm	**61.78**	**70.63**
- 8mm + 4mm	**5.33**	**8.45**
- 4mm + 2mm	**0**	**0**
- 2mm	**0**	**0**
TOTAL	**100**	**100**

In the marine application, some of the Ferrosilicon (FeSi) used in the DMS process is entrained in the G-shell and consumption reaches figures of up to 7kg/ton DMS feed during the treatment process. Furthermore, the carry over of high percentages of floats and FeSi to the DMS concentrate causes downstream treatment problems in final recovery, in terms of FeSi dust generation and increased concentrate volumes. These problems led to a major drive to try and solve the treatment issues regarding shell and especially the G-shell.

During 2002 Namdeb took this investigation further and approached Gekko systems in South Africa for a quote on three IPJ 2400's, planned for installation on the FTP. Design and modeling of the IPJ circuit was based on experiences at WDL, DBMSA, ADP and Gekko [8,9,10]. Based on the modeling it was decided to order three IPJ 2400's for the primary purpose of G-shell removal ahead of the DMS process. One IPJ for treating coarse material (-25+8mm) and two for treating fines material (-8+2mm) giving the IPJ circuit an overall capacity of 240tph. The IPJ's were installed during September 2003 and commissioned during November and December 2003.

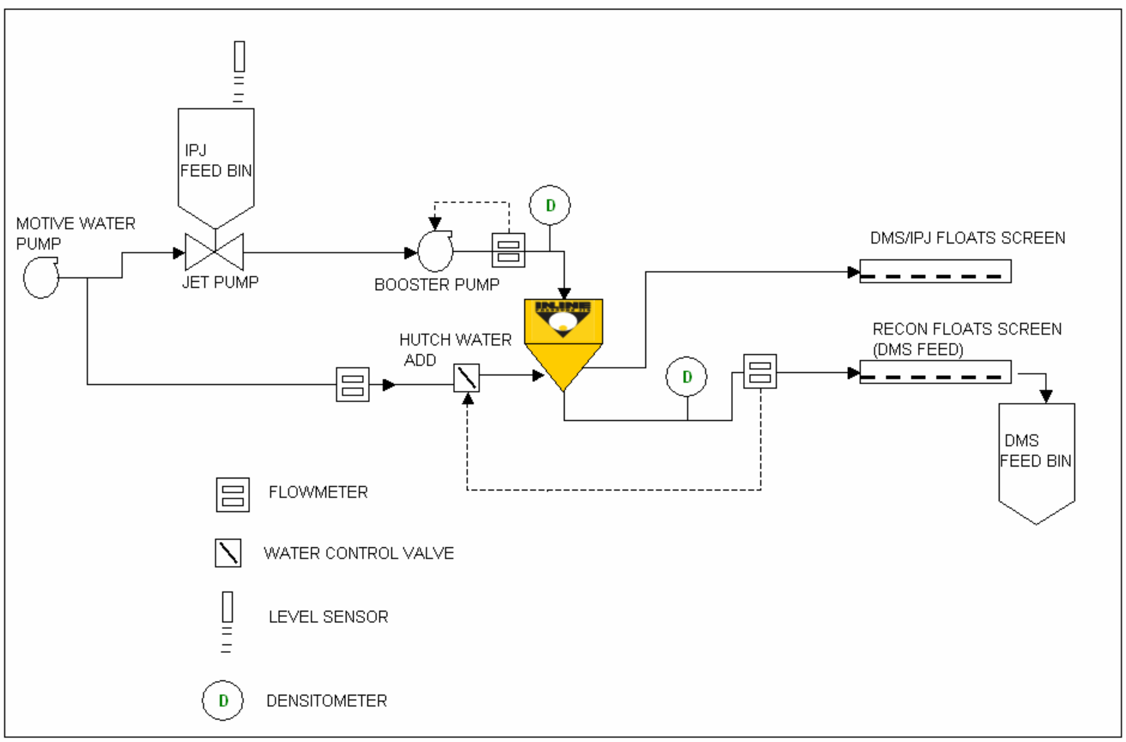

Figure 17: Automation Schematic for IPJ Plant – Namdeb design

Goals achieved:

The following results goals were achieved after the installation of the IPJ's:

- High percentage floats (up to 80%) previously experienced in the DMS concentrate was reduced to 20% with 95% removal of G-Shell. The remainder of the floats consist mainly of flat shell.
- The FeSi consumption of the FTP reduced from 6kg/ton to about 1kg/ton.
- The DMS feed was reduced from 200tph to 50tph.
- The overall cost per ton for the FTP operation was decreased by 10% due to the IPJ installation resulting in an overall cost saving of N$ 5.5mil on an annual budget of N$ 50mil for 2004.

Unfortunately the FTP burned down at the end of 2004 and the Rebuilding project has been postponed until middle 2006.

Diamond loss determination

Due to the design of the IPJ circuit on the FTP, metallurgical accounting was extremely difficult. Spot checks were done on the floats of all three of the jigs to try and determine the quantity of misplaced material above a density of 2.95 (the density for TBE). Namdeb was not in a position to do full densimetric analysis nor was it possible to do tracer tests on these process units. The only information that could give us an indication on whether we were misplacing diamonds to the floats was the current vs. historic diamond Size Frequency Distribution data for the FTP operation. A shift in this graph would indicate a loss or gain in the respective area where the change occurred. Figure 18 shows the diamond SFD for the FTP operation prior to IPJ installation versus post IPJ installation. From this graph it can be seen that there is no indication of significant diamond loss to IPJ floats in any size fraction.

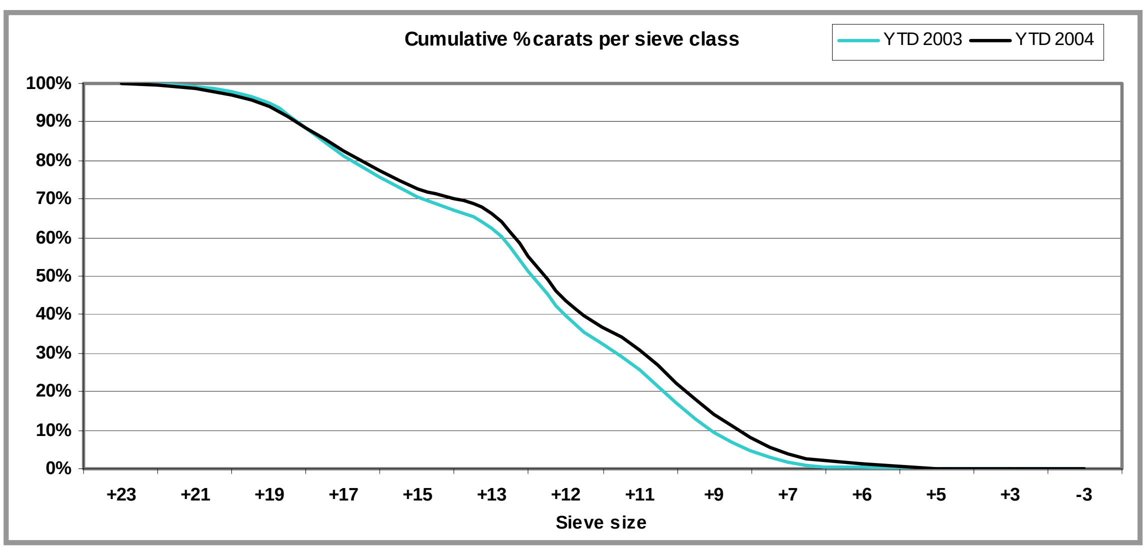

Figure 18: Diamond SFD's prior (2003) and post (2004) IPJ installation

2b): NAMDEB DIAMOND CORPORATION – NAMIBIA – IPJ TEST WORK ON CLAY REMOVAL

During 2003 Namdeb placed an order on ADP in Cape Town to build an IPJ test facility for the purpose of exploring the possibilities of the technology further. A mobile test plant was built consisting of a tipping bin, a screening section and a IPJ circuit that enables test work to be performed on any type of material at any desired size range.

Figure 19:IPJ Test Plant - Namdeb

TEST 1: CLAY REMOVAL
One of the plants at Namdeb was treating material with high percentages of clay in the feed. The clay was hard and did not breakdown during normal scrubbing processes causing continuous generation of slimes throughout the process. This causes extremely difficult screening conditions and viscosity problems in the DMS. Clay rich material was then sent to the IPJ test plant and sized into two fractions, -25+12mm and -12+2mm, for further test work.

GOALS SET FOR THIS TEST:

- Optimise IPJ to achieve optimum clay removal and maximum diamond recovery.
- Determine the influence of the following control parameters on the IPJ efficiency:
  - Ragging depth
  - Pulse rate
  - Stroke Length
  - Up-flow water volume
- Use TBE to determine % sinks in floats at a density of 2.96.

TESTWORK

As a precursor to the trial, a batch of low-grade clay rich material was transported to the IPJ test plant where it was to be treated.

The material was fed through the plant, where it was screened into two size ranges, -25+12mm and -12+2mm and then stockpiled for separate treatment through the IPJ.

The feed to the IPJ consisted of marine gravels with an average specific gravity of 2.65 and 15% to 20% clay with an average specific gravity of 1.6. A total of 500 dry tons of material was treated through the IPJ as part of the batch tests.

This test work is currently in, and none of the results can yet be quantified in terms of diamond/tracer loss by using either magnetic tracers or Radio Frequency Identification Technology (RFID). Magnetic tracers could not be used due to the high percentage of magnetic material in the IPJ feed which made the recovery of the magnetic tracers impossible, the intention is to repeat the tests using the newly available RFID tracers in early 2006.

However, the results achieved which are available are presented in Table 7.

Table 7: Clay removal results achieved

Size Fraction Mm	**Mass split Sinks/floats**	**Clay removal %**	**Misplacement @ 2.96 SG (TBE)**
-25+12mm	15/85	98-100	d_{70}
12+2mm	20/80	98-100	d_{75}

TEST SUMMARY

By comparing the percentage mass pull to sinks it can be said that the IPJ test work on clay rich material looks promising. The WDL test work indicated very good tracer recoveries at these percentages of mass pull to sinks.

Further test work will commence during February 2006 to determine the efficiency of the IPJ in terms of diamond recovery.

CONCLUSIONS

The test programme carried out in Tanzania, jointly between Gekko Systems, and De Beers, and the continuing commitment of the Namdeb Diamond Corporation to the installation of InLine Pressure Jig technology for diamond pre-concentration, leaves little room for doubt about the applicability of the technology.

The test results generated from the Williamson work, in terms of EPM values and also partition curves substantiate this position and provide invaluable data for potential new IPJ applications both within the De Beers group and for the diamond industry as a whole. Further test work at Namdeb on diamond recoveries will assist in developing this technology and understanding its potential and limitations.

The economic potential of the InLine Pressure Jig in terms of capital and operating cost reduction has been proven by the first production installations at Namdeb.
Now that operational data for the diamond recovery of the technology is available, the application of the IPJ specifically for diamond recovery has been finally confirmed.

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