Gekko IPJ Coal Separator Performance in Coal Preparation

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ABSTRACT

The Gekko IPJ Coal Separator (GICS) is based on a circular design and is capable of processing a wide particle size range (- 30 + 0.25 mm, i.e. - $1^3/_{16}$ inch + 60 mesh). For coal in particular, the GICS can process size fractions that include the smaller of those conventionally processed by dense medium cyclone (DMC) units (eg - 2 + 0.5 mm or - 9 + 32 mesh) and all of those typically processed by spirals and teetered bed separators (- 2 + 0.125 mm or - 9 + 115 mesh). Indicative capacities are in excess of 200 tonne/h for a 3.5 m (11.5 ft.) diameter unit with separations close to the washability curve. The major advantage of the circular design of the GICS unit is that capacity increases with the square of the unit's diameter.

Pilot scale and modular plant test results are reported for when the GICS unit was processing coals from the Hunter Valley and Bowen Basin regions in Australia. They embraced easy (low near gravity) and harder (higher near gravity) to process raw coals and the results indicated that high recoveries could be achieved in all cases with the GICS deployed either in rougher only or rougher scavenger (simulated) configurations. An example of a coal preparation plant circuit is given that shows how the GICS unit can add significant value to overall plant operations. With some coals a rougher only configuration is appropriate, while for the more difficult to separate coals, a rougher-scavenger configuration may be recommended. Benefits of including the GICS unit in a coal preparation circuit are derived from high coal recovery over a broad size range combined with the debottlenecking and other beneficial effects of increasing desliming screen apertures.

Avenues for further improvement to the design of the GICS include: improved feed distribution via a blind cyclone, increased number of ragging layers and better containment of the ragging particles. As higher capacity has been demonstrated to be linked to better separations (lower Eps), it is also recommended that units larger than 3.5 m (11.5 ft) are built and tested.

INTRODUCTION

The Gekko IPJ Coal Separator (GICS) has evolved from the Gekko In-Line Pressure Jig (Gray, 1997), which has found many applications in the metalliferous industries during the last 15 or so years. The GICS machine undertakes gravity separations and is generally applicable to processing coal slurries with a 30 mm ($1^3/_{16}$ inch) particle top size. In this investigation, its performance with raw coal slurries with a 6 mm ($^1/_4$ inch) top size was investigated in the laboratory and in a Hunter Valley (New South Wales, Australia) coal preparation plant.

It has become standard coal preparation plant design practice in Australia (Mackinnon and Swanson, 2010) to include mid-sized (eg - 1.4 + 0.25 mm or - 12 + 60 mesh) circuits as they are an effective means of achieving remarkable capital efficiency with respect to both new and upgraded plant capacities. The capital efficiencies are achieved by the increased throughputs enabled by simply increasing screen apertures from, for example 0.5 to 2 mm (32 to 9 mesh). Material that was previously processed by DMC units in the - 2 + 0.5 mm (- 9 + 32 mesh) size range is now commonly passed to other machines eg spirals (Bethell, 2010), teetered bed separators (Drummond et al., 2002) and less commonly, reflux classifiers (Galvin et al., 2004). As these devices handle material with sizes down to around 0.125 mm (115 mesh), less material is either discarded or treated by flotation.

There are also likely to be efficiency benefits achieved in some cases due to the reduction of the cut point size drift that commonly occurs in DMC units, as shown in recent empirical (Meyers and Sherritt, 2010) and fundamental (Vince et al, 2010a) investigations on large diameter DMC devices. In addition, increasing the top size processed by the mid-sized coal circuit would increase the mean size processed by DMC units and so increase their efficiency. This could also provide a means to allow efficient even larger diameter DMCs to be installed industrially as the breakaway size (Bosman 1998; Bosman and Engelbrecht, 1997) limitations may be circumvented. Additionally, flotation circuits would not be required to process the more troublesome coarser (- 0.5 + 0.3 mm (- 32 + 48 mesh)) particles, thereby increasing overall coal recovery.

The obvious next step of increasing desliming screen aperture to larger sizes is likely to provide commensurate capital benefits. However, this has not yet occurred, primarily due to the absence of a proven single stage technology to efficiently process the intermediate size material.

The GICS offers the potential to provide an industrial solution to this problem as the technology has been proven in the metalliferous industry (Gray, 1997) and can readily be adapted to coal applications (Vince et al, 2010b, c). A structured investigation was undertaken involving laboratory and modular-scale site testing, with the latter undertaken at an industrial coal preparation plant located in the Hunter Valley (New South Wales) of Australia.

DESCRIPTION OF THE GEKKO IPJ COAL SEPARATOR

The GICS unit (Figure 1) is a compact, continuous circular processing unit that requires minimal infrastructure or operational support. The remarkable feature of the circular design is that it leads to both throughput capacity and separating efficiency being directly related to its diameter. This is unlike more conventional jig designs where throughput capacity is linked to width and separating efficiency is linked to length. Therefore, by increasing the size of the GICS unit, both capacity and separating efficiency would be expected to increase.

Figure 1. Schematic representation of GICS

The GICS is characterised by low operational costs as well as by low power and low water requirements when compared to conventional jigs (Gray, 1997). The unit is a development of the Gekko In-Line Pressure Jig (Gekko Systems, Ballarat, Victoria, Australia) originally designed to beneficiate hard rock minerals. The first unit was sold in 1996 and over the following 15 year period there have been over 120 installations worldwide. It has been used industrially to beneficiate 10 different minerals, including diamonds, gold, silver, lead/zinc, tantalum, tin, copper, manganese, cobalt and garnet.

The unit is fully encapsulated, pressurised, and combines a circular bed with a moveable sieve action. The encapsulation allows the GICS to be completely filled with slurry and water. As a result, slurry velocity is slowed and water surface tension effects are eliminated thereby improving beneficiation potential for the finer sizes.

The GICS unit differs from a conventional jig in the way the jigging action is imparted. Conventional jigging units characteristically dilate the particle bed by an upward pulse of water, through a screen, caused by the movement of a remote piston (Wills, 1997, Alderman, 2002). However, the GICS unit moves the screen up and down in a cyclic manner by means of a hydraulically powered servo that is mechanically linked to the screen. The direct mechanical linkage to the screen provides good control of both the bed dilation stroke (downward screen movement) and the settling stroke (upward screen movement). In addition, there is good control of the screen motion such that a sawtooth displacement/time profile can be provided (Nesbitt et al, 2005). This is unlike the case of a conventional jig where the settlement stroke is dictated by the settling velocity of the feed charge. In addition to this improved control, hutch water feed, which results in an independent upward flow of water, can be used to further improve the separation.

Coal separation is based on particle relative density (RD) as well as particle size and shape. High RD particles are drawn into the hutch during the suction stroke of the bed and are continuously discharged. The lighter material is discharged over the tailboard to the outer cone. Both heavy and light materials are discharged under pressure.

As the screen plate apertures are greater than those of the slurry particles, it is necessary to use inert ragging particles in a similar way to feldspar in fine coal jigs (Sanders, 2007). The ragging particles add a further degree of control over the separation as their size, shape, RD and number of layers and can be adjusted.

It is considered that the GICS unit may be a viable alternative to some existing coal preparation plant equipment as well as providing unique processing capabilities and facilitating overall plant capacity increases.

DETAILS OF THE GEKKO IPJ COAL SEPARATOR UNITS USED FOR TESTING

Laboratory Scale Unit

The laboratory scale GICS 600 unit was a single hutch, circular jig with a moveable screen in which feed entered into the centrally located distributor, where the velocity reduced as the slurry radiated across the circular bed (Figure 2). The bed comprised an 8 mm wedge wire screen plate on which ragging particles were placed. The ragging consisted of 16 mm diameter ceramic spherical particles. Two sets of ragging particles were used, one with 1.60 RD and one with 1.80 RD. The ragging particles were larger than the wedge wire screen apertures and formed a bed of around three to four particles deep.

Figure 2. GICS feed inlet detail (Vince et al., 2007)

As the screen pulsed in a vertical plane with a saw tooth action, particle segregation was promoted as the jig downward motion was faster than the settling velocity of the feed solids and ragging particles. As the entire unit was encapsulated, the unit operated under pressure (up to 200 kPa or 29 psi), and periodically air needed to be bled from the unit. This also ensured that there were no air/slurry interfaces interfering with the process.

In order to maintain the pressure in the separator, both the product and reject lines were elevated so as to provide a barometric head. In practical terms, this created difficulties with blockages. This problem was overcome for the modular scale site-based test work by using blind cyclones (orifices) on the outlet lines in which the swirling actions created the necessary back-pressure. In larger GICS units, process controlled pinch valves may be used to maintain pressure and flow in the sinks and floats lines.

The unit was fitted with a relatively complex set of actuators and sensors that were part of a PID control system. In simplified terms, the parameters controlled were: stroke amplitude, stoke frequency and a sawtooth stroke shape. In addition, ball valves and magnetic flow meters on each of the hutch water and tailings flows allowed these parameters to be adjusted manually and independently.

Modular GICS Unit

A GICS 1000 skid-mounted modular unit was used for site-based test work (Figure 3) with a nominal throughput of around 5 tonne/h. The GICS unit was fed continuously with - 6 mm raw coal slurry from a Hunter Valley coal preparation plant.

Figure 3. Skid mounted 5 tonne/h GICS on site

TEST WORK CONDUCTED

Laboratory Scale Tests

The tests were conducted at the ALS Coal Technology Maitland (New South Wales, Australia) pilot plant facility (Vince et al., 2007). In brief, the tests comprised four series: Series 1 used a Hunter Valley coal and processed 6 to 0.5 mm ($^{1}/_{4}$ inch to 32 mesh) particles in slurry form with monosized ragging (16 mm or $^{5}/_{8}$ inch) and two different ragging RDs (1.60 and 1.80). Series 2 replicated Series 1 except that a Bowen Basin coal was used. Series 3 and 4 replicated Series 1 and 2 respectively, except that – 6 + 0.25 mm coal was tested. The Series 3 and 4 tests allowed the performance to be assessed at finer sizes.

Sample preparation. As raw coal samples were provided by Hunter Valley (New South Wales) and Bowen Basin (Queensland) coal mines in Australia, the size fractions of interest (- 6 + 0.5 mm and - 6 + 0.25 mm (115 mesh)) had to be produced and separated before the tests could be conducted. The pilot facility was configured such that each raw coal type was initially screened at 6 mm with the oversize passed to a pick roll crusher. Crusher product was again screened at 6 mm with oversize further crushed. This procedure was repeated until there was no plus 6 mm material remaining (after three stages of crushing). Once crushed, for each coal type, the pilot facility was arranged such that – 6 + 0.5 mm and -0.5 + 0 mm fractions could be separated. This involved placing 0.5 mm panels on the appropriate screens. The – 6 + 0.5 mm material was collected in a product bin, while the minus 0.5 mm fraction was passed to a freshly cleaned and flushed thickener (with no flocculent added). The thickener underflow was passed to a 1.5 m diameter vibratory Kason unit fitted with a 0.25 mm aperture screen. Figure 4(a) is a schematic representation of this procedure.

For Series 1 and 2 tests, the – 6 + 0.5 mm size fraction was used. For the Series 3 and 4 tests using the -6 + 0.25mm material, the Kason oversize material was mixed with the – 6 + 0.5 mm material by repeated solids passage through one 2 tonne hopper to another, see Figure 4(b).

Figure 4. GICS feed preparation

The laboratory facility configuration for testing the laboratory scale GICS is shown schematically in Figure 5. The sized raw coal was charged from a tip truck to the ten tonne raw coal hopper, and then conveyed to a feed sump into which dilution water was added. A VVVF pump delivered the test slurry to the GICS, which separated product and reject fractions. 0.5 mm aperture screens were used to dewater the product and reject streams, with the recovered water reporting to a thickener, the overflow from which was recycled.

Figure 5. Schematic representation of laboratory scale GICS test circuit

Sample testing. For the tests with – 6 + 0.5 mm solids, approximate 100 litre timed samples of the complete dewatering screen overflow discharge were collected in a single increment. For the tests with – 6 + 0.25 mm solids, timed samples were collected from the barometric leg discharges (A, B, C) before entering the 0.5 mm aperture screens.

Modular GICS unit

This test work was conducted at an industrial coal preparation plant in the Hunter Valley of New South Wales (Australia) and full details are provided elsewhere (Vince et al, 2010b). In brief, the set up for the site-based testing of the modular GICS is shown schematically in Figure 6.

Figure 6. Schematic representation of site based testing of modular GICS

Raw – 12 + 0 mm (- ½ inch + 0) coal that was separated during normal operation at the test site was first passed to a 6 mm sieve bend, with undersize material passing to a thickening cone designed to increase solids concentration to approximately 15% by weight. Thickening cone underflow was pumped at 150 to 200 kPa (22 to 29 psi) to the modular GICS unit. Hutch water was also passed into the GICS unit. Following separation in the GICS, product and reject slurry reported to separate "blind" cyclones. These units had one inlet and one outlet and provided back pressure to the GICS. Figure 3 shows a photograph of the test unit on site.

During a test, 5 to 7 sample increments of feed were obtained from position D by cutting a complete falling stream. Sample increments of product and reject were taken at positions E and F, respectively, again by cutting full streams.

Tests were conducted at 20.5 – 29.0% solids by weight with dry feed rates between 3.2 and 4.8 tonne/h. Hutch water flow rates were between 11.5 and 25.1 m^3/h (51 and 111 GPM). The stroke lengths tested were 15 mm and 10 mm ($^5/_8$ inch and $^3/_8$ inch), frequencies tested were 60, 80, 90 and 100 cycles/min and the ragging RDs tested were 1.8 and 1.6.

RESULTS

Laboratory Scale GICS Unit

Each test condition for which complete partition coefficient data were determined is shown in Table 1, in which HV denotes a Hunter Valley coal and BB denotes a Bowen Basin coal.

Table 1. Test conditions for partition coefficient determinations

Partition Curves

Hunter Valley coal partition curves are shown in Figure 7, which indicates that the expected result that the separation of the – 6 + 2 mm particles was significantly sharper than for the – 2 + 0.5 mm particles. The separation for the – 2 + 0.25 mm particles was the least efficient with significant high density tails present, indicating some rejects reported to product. The low density tail was not significant. Table 2 summarises the cut point (D_{50}) and Ecart Probable (Ep) values. For the – 6 + 2 mm particles, Ep values are higher than those expected in a DMC, but for the – 2 + 0.5 mm and – 2 + 0.25 mm particles, the Ep values were similar to those expected of a spirals operation.

All tests with Hunter Valley coal were conducted using 1.60 RD ragging particles, and the coarse particles were separating with cut points a little lower than the ragging RD (1.54-1.55 versus 1.60). The cut points for the finer particles were higher than the ragging RD. This indicates that different mechanisms of separation may be occurring for the coarser and finer particles.

Figure 7. Hunter Valley Coal Partition Curves

Table 2. Hunter Valley Coal D_{50} and Ep values

Similar results were obtained for Bowen Basin coals with partition curves shown in Figure 9 and D_{50} and Ep data summarised in Table 3.

Figure 9. Bowen Basin Coal Partition Coefficient Curves

Table 3. Bowen Basin Coal RD_{50} and Ep values

Except for Test 25, the separation of the – 6 + 2 mm particles was significantly sharper than for the – 2 + 0.5 mm particles. The separations for the – 2 + 0.25 mm particles were the least sharp with significant high density tails, indicating significant amounts of reject reporting to product. The low density tail was not marked. The feed rate used for Test 25 was very high (2.4 tonne/h) and the unit was considered to be overloaded.

Operating Points

The above discussion has examined the separating characteristics in terms of partition coefficient curves. An alternative way is to look at how close the actual separation was to perfect separation, as estimated by the washability curve. To do this, two processing circuits were considered. In the first, termed “Rougher only”, the results for the actual separation determined during each test are recorded. In the second, termed “Rougher-scavenger”, a reject retreatment process has been postulated (see Figure 10) and the results determined by simulation using the measured partition coefficient curve for the “Rougher only” circuit.

Figure 10. Schematic rougher-scavenger configuration circuit for Gekko IPJ Coal Separator

For Hunter Valley coal, the data shown in Figure 11 indicate that the Rougher only operating points were very close to the washability curves, demonstrating high organic efficiency. It should be noted that the operating points tended to be above the “knee” in the respective washability curves, indicating that the separations were occurring in regions of relatively low near gravity. For the simulation of the reprocessing of rougher tails, the operating point moves to a higher overall ash level and to a position a little closer to the respective washability curve. Similar findings are shown on Figure 12 for tests with Bowen Basin coal.

Figure 11. Measured rougher only and simulated rougher-scavenger operating points for Hunter Valley coal laboratory tests

Figure 12. Measured rougher only and simulated rougher-scavenger operating points for Bowen Basin coal laboratory tests

Modular GICS Unit

Each test condition for which full partition coefficient curves were determined is shown in Table 4.

Table 4. Summary of test conditions

Partition Coefficient Curves

Figure 13 shows that reasonable partition coefficient curves were determined for the individual and combined size fractions considered for tests involving coals A, B, CI and CII respectively. None of the curves display significant low density tails, however the - 2 + 0.25 mm size fraction shows a high density tail, which implies there was evidence of reject in the product.

Figure 13. Partition coefficient curves for modular GICS tests with Coals A, B and C (I and II)

Table 5 summarises the D_{50} and Ep values. For the – 6 + 2 mm particles, Ep values are higher than those expected in a DMC, but for the - 2 + 0.5 mm and -2 + 0.25 mm particles, the Ep values are similar, although a little larger, to those expected of a spirals operation.

Table 5. Modular GICS D_{50} and Ep values

Operating Points

Figure 14 shows a comparison of washability data with modular unit operating performance as measured (Rougher only) and a simulated rougher-scavenger configuration for all coals tested. Similar results were found to those determined at the laboratory scale. Important differences were that some separations were conducted on the steep part of the washability curve, which indicates that higher levels of near gravity were encountered. The effect of this would be to increase the distance of the operating points from the respective washability curves. This is shown in particular for Coal CI. The effect is overcome with the aid of the scavenger circuit, which tends to move the operating point closer to the washability curve, albeit at a higher overall product ash.

Figure 14. Modular Gekko IPJ Coal Separation performance relative to washability curves

DISCUSSION

Scale – Up

A comparison of data from the 600 mm and 1000 mm diameter units provides an indication of how performance is affected by unit size, see Table 6.

Table 6. Laboratory and Modular GICS D_{50} and Ep values

This indicates that the larger scale unit has lower Eps than the smaller scale unit. The manufacturer indicates that this is to be expected as scale-up is achieved by increasing the diameter of the circular-section machine, which is in contrast to Baum or Batac jigs. With the non-circular jigs, capacity is related to width and separating efficiency is related to length. As increasing the diameter of the Gekko IPJ Coal Separator unit can be regarded analogously to effectively increasing the width and length, both the capacity and separating efficiency would increase with diameter.

Indicative Capacity of Gekko IPJ Coal Separator

Only small units were tested in this investigation with dry feed rates up to 9 tonne/h. Larger units are available with, as can be seen in Table 7, much larger unit capacities.

Table 7. Indicative capacities of Gekko IPJ Coal Separator

It is important to note that the capacity increases with the square of the unit's diameter (see Figure 15). This is a major inherent advantage of the circular design of the unit.

Figure 15. Indicative capacity of GICS

In addition, due to the high unit capacity of GICS units, there would be much less need to use multiple units for a given duty. There would, therefore, be less need to split a feed stream than, for example, for a circuit involving spirals, and so the inherent single unit separating efficiency is more likely to be maintained in full scale plant applications.

Important Applications of Gekko IPJ Coal Separator

There are a number of important applications for the GICS either in rougher only or rougher-scavenger configuration. A schematic representation of an example of how the Gekko IPJ Coal Separator could be used to add value in a coal preparation plant is shown in Figure 16. In the application shown, - 50 mm (2 inch) raw coal is screened at 2 mm (9 mesh) with the oversize passing to a DMC circuit and the undersize passing to a classifying cyclone module. The classifying cyclone module would be used to exclude slimes from the GICS feed.

The inclusion of GICS in the process circuitry reduces the criticality of the screen aperture size as, unlike spirals, the unit can effectively process material much larger than 2 mm. In fact, the screen aperture could by design be increased significantly to, say, 6 mm ($^{1}/_{4}$ inch), but the decision to do so would be coal type dependent with the relative processing efficiency of the DMC and rougher-scavenger GICS circuits being considered along with the overall plant throughput capacity to maximise the profitability of a given mine site. In the circuit shown, the finest sized material would be passed to flotation.

Figure 16. Schematic representation of a possible coal preparation circuit utilising a Gekko IPJ Coal Separator

The effect of using 2 mm or larger desliming screen apertures would:

1. Make the screening more efficient
2. Increase screen capacity
3. Lead to low cost overall plant capacity increases
4. Lead to possible yield increases through better matching of incremental ash values of DMC and mid-sized circuit products
5. Be possible because, unlike spirals, the Gekko IPJ Coal Separator is not limited to particles less than 1.5 mm
6. Reduce the effect of breakaway size on DMC performance by increasing the size of the finest particles processed. This would likely be additionally beneficial as DMC units grow larger in diameter
7. Improve magnetite recovery as the apertures of drain and rinse screens could be increased
8. Reduce the amount of dense medium that is required for efficient DMC operations
9. Have no effect on flotation

Potential to separate very clean product. The strength of the design of the Gekko IPJ Coal Separator is to produce a very clean product. That is, the high density tail of the partition coefficient curve tends to be minimised. This lends the device to applications where a product devoid of contamination is an advantage. Industrial applications in this regard include parallel circuits, eg DMC circuits, which process high levels of near gravity material. In such circumstances a low ash fines product would permit DMC medium densities to be increased, with commensurate yield increases.

Other Applications.

These include:

- Fine coal processing with up to 6 mm top size. The efficient processing of this size fraction in the Australian coal industry is becoming more and more important. This is due mainly to low-cost means of feed rate increase afforded by increasing the desliming screen aperture from, eg, 0.5mm to 2mm. This size fraction is traditionally either processed by spirals (where the top size for spirals are limited to 1.5mm and low cut points are not achievable) and teetered bed separators (where efficiency is compromised by large cut point variations with size). As both these devices have separating efficiencies inherently lower than DMCs, the Gekko IPJ Separator offers the potential for size range and efficiency benefits.
- Beneficiating - 6 + 2 mm particles. This size fraction is typically processed in either high cost dense medium circuits or older-technology conventional jigs (Batac or Baum). The operation of the Gekko IPJ Coal Separator does not require an ancillary dense medium recovery circuit and its operation is characterised by nil consumables and low water consumption.
- Flotation tails scavenging. The potential for this application is high due to its self-screening action and low cut point capability.

Suggestions for improving performance

Avenues for further improvement to the design of the GICS include:

1. Improved feed distribution via a blind cyclone.

2. Increased number of ragging layers.
3. Better containment of the ragging particles.

SUMMARY AND CONCLUSIONS

1. The major advantage of the circular design of the GICS unit is that capacity increases with the square of the unit's diameter.
2. Results indicate that separating efficiency increases (Ep decreases) with the diameter of the GICS unit tested.
3. The Gekko IPJ Coal Separator has important applications in main stream coal preparation in rougher only and rougher-scavenger configurations, depending on the coal processed.
4. The Gekko IPJ Coal Separator1000 was able to process raw coal while on site in the Hunter Valley with partition coefficient curves that were superior to those obtained in the laboratory with a smaller unit.
5. This modular scale unit was able to achieve good separation efficiencies over a very wide range of cut points:
    a. D_{50}: 1.43 -1.88, Ep: 0.057 - 0.112 for - 6 + 2 mm particles.
    b. D_{50}: 1.49 - 1.91, Ep: 0.172 - 0.223 for - 2 + 0.25 mm particles.
6. Inherent in the design of a circular jig is the linking of capacity and efficiency: higher capacity is achieved by increasing the diameter which also improves the efficiency.
7. The Gekko IPJ Coal Separator can add significant value to the coal preparation industry by a combination of significantly higher throughputs from existing plant circuitry and efficiency increases. It is also capable of separating a very clean product.

It is concluded that the Gekko IPJ Coal Separator makes efficient separations in the 1.43 – 2.0 RD range for particles in the - 6 + 2 mm and - 2 + 0.25 mm size ranges and as such has direct application in the coal industry. It is very likely that the unit can effectively process a very wide range of particle sizes and straight forward minor design changes have been identified that would enhance the performance of the Gekko IPJ Coal Separator further.

RECOMMENDATIONS

Avenues for further improvement to the design of the GICS include: improved feed distribution via a blind cyclone, increased number of ragging layers and better containment of the ragging particles. As higher capacity has been demonstrated to be linked to better separations (lower Eps), it is also recommended that units larger than 3.5 m (11.5 ft) are built and tested.

It is also recommended that a means of changing independently stroke length and frequency are introduced into the control box of the Gekko IPJ Coal Separator.

NOMENCLATURE

D_{50}	Cut point (RD units)
Ep	Ecart probable (RD units)
RD	Relative density (dimensionless)
±0.1RD	Near gravity (mass per cent within 0.1RD units of the cut point).

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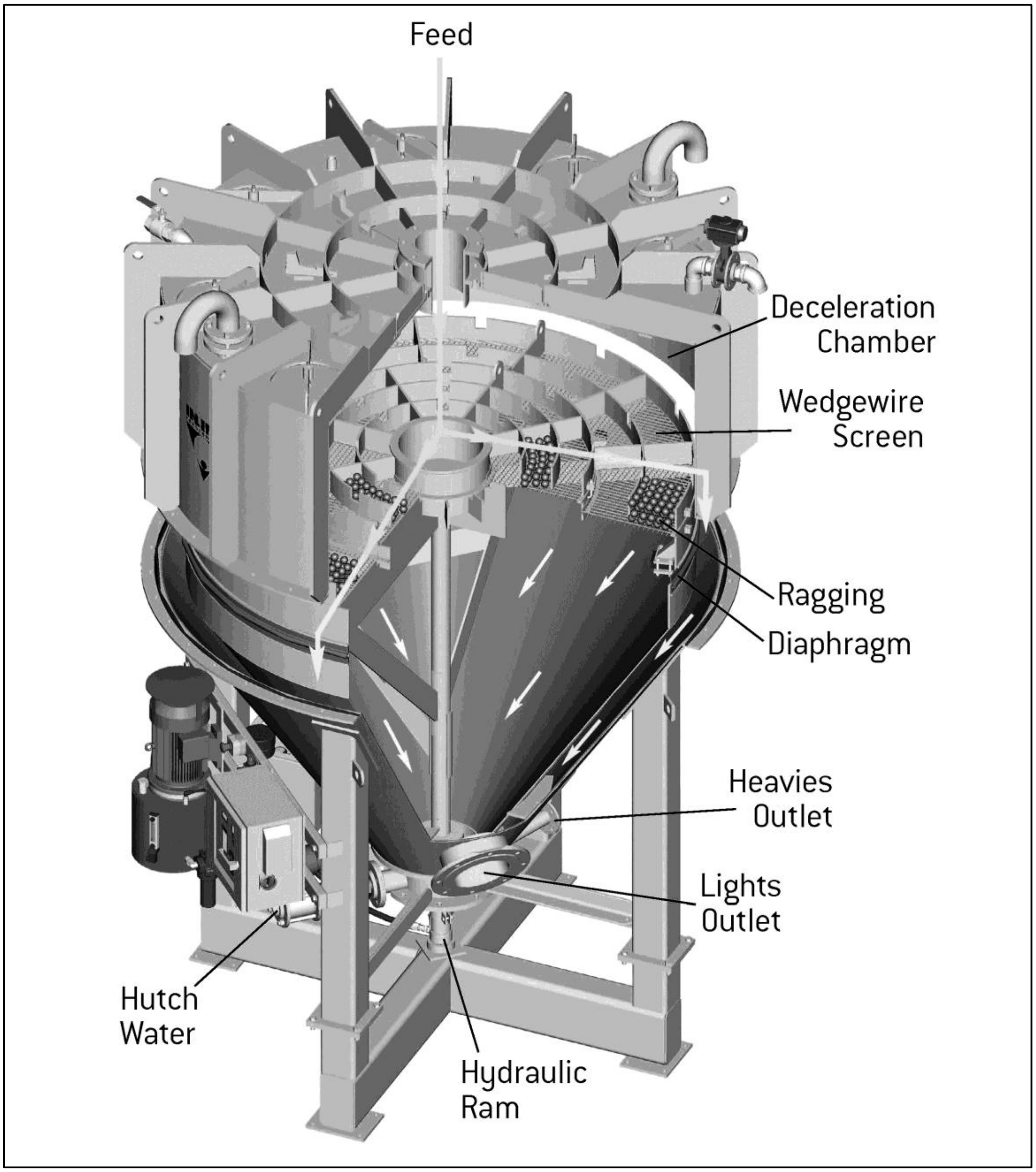


Figure 1. Schematic representation of GICS

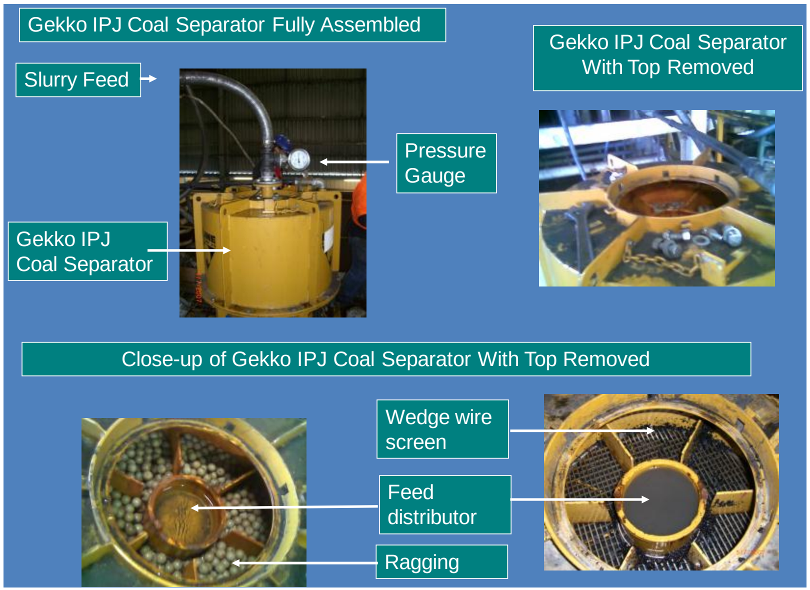
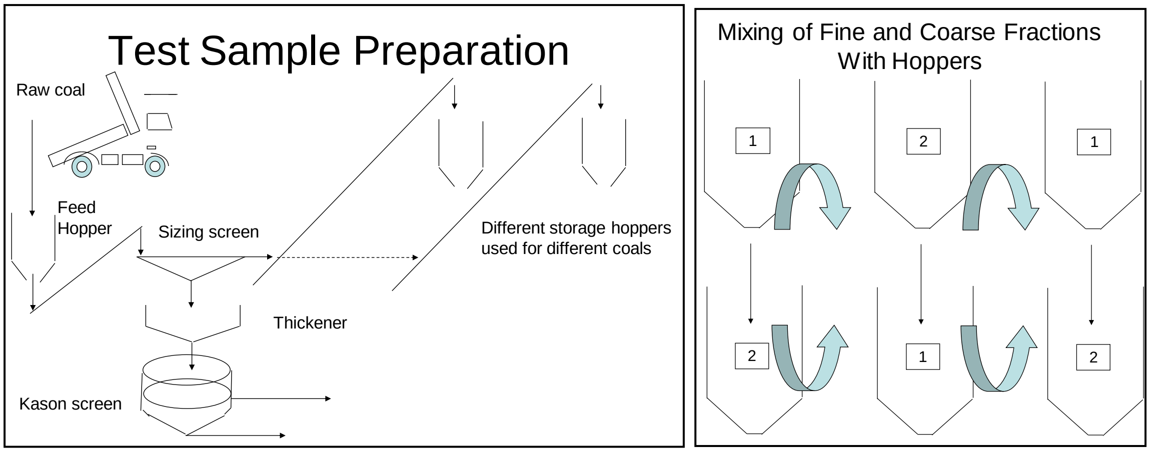


Figure 2. GICS feed inlet detail (Vince et al., 2007)

Figure 3. Skid mounted 5 tonne/h GICS on site



(a) Laboratory plant configuration

(b) -6+0.5 mm and -0.5 mm +0.25 mm solids mixing using 2 tonne hopper

Figure 4. GICS feed preparation

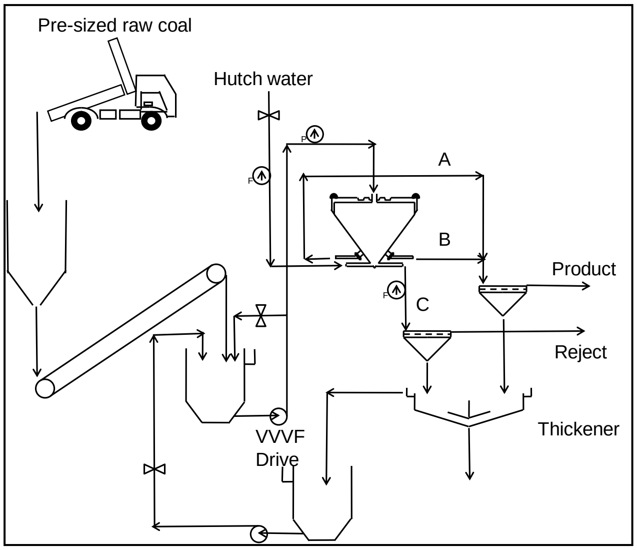


Figure 5. Schematic representation of laboratory scale GICS test circuit

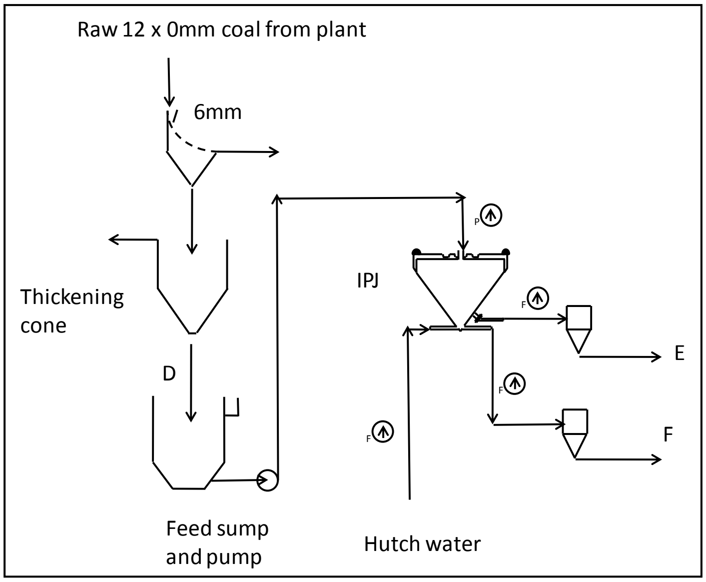
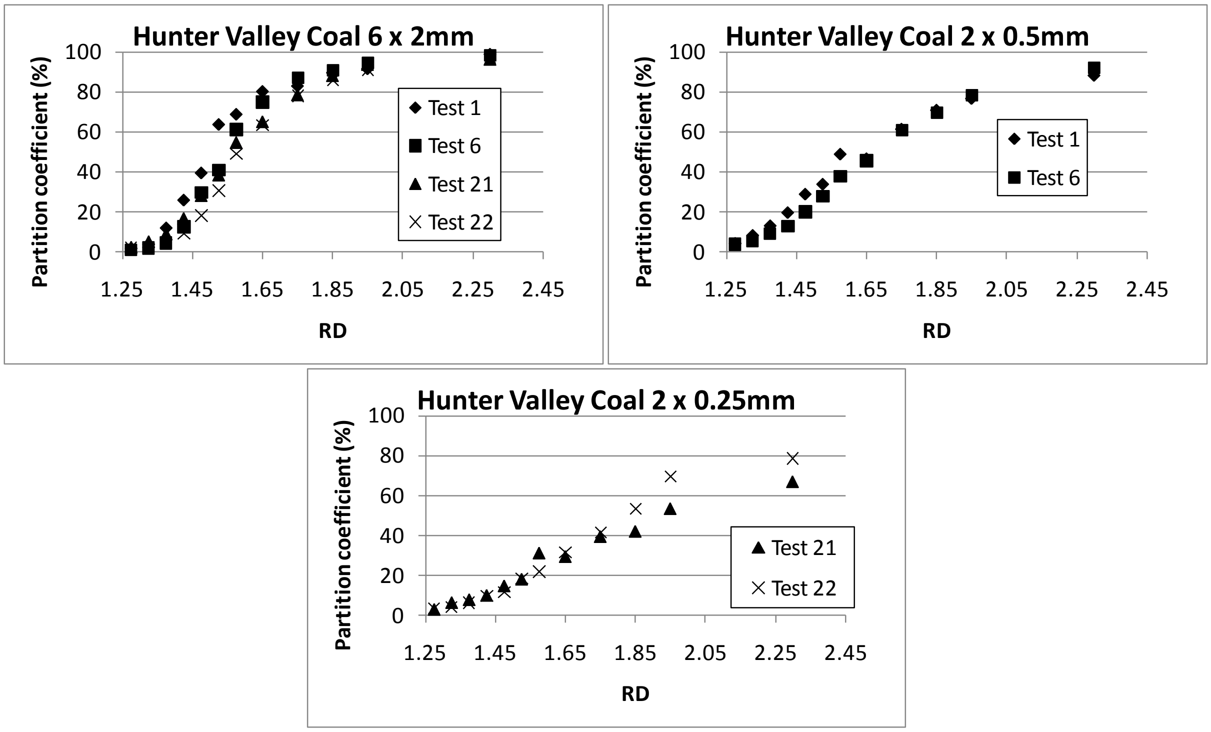


Figure 6. Schematic representation of site based testing of modular GICS


Hunter Valley Coal 6 x 2mm

Hunter Valley Coal 2 x 0.5mm

Hunter Valley Coal 2 x 0.25mm

Figure 7. Hunter Valley Coal Partition Curves

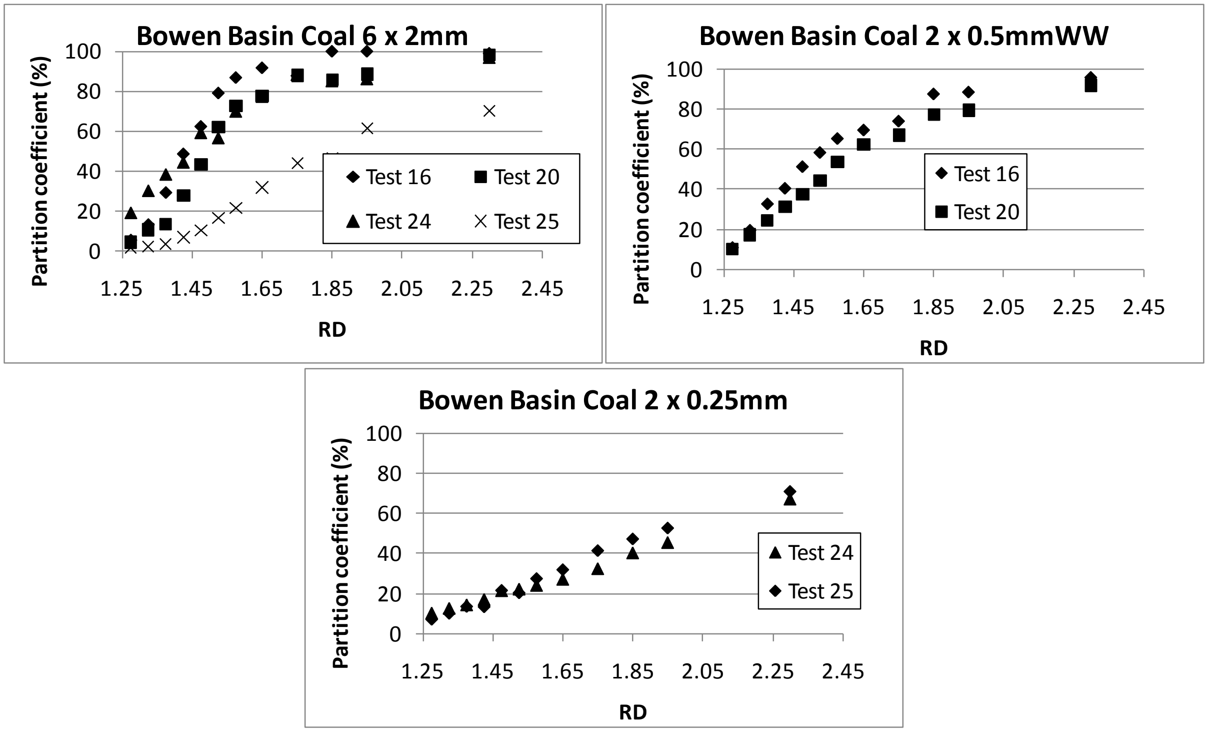


Figure 9. Bowen Basin Coal Partition Coefficient Curves

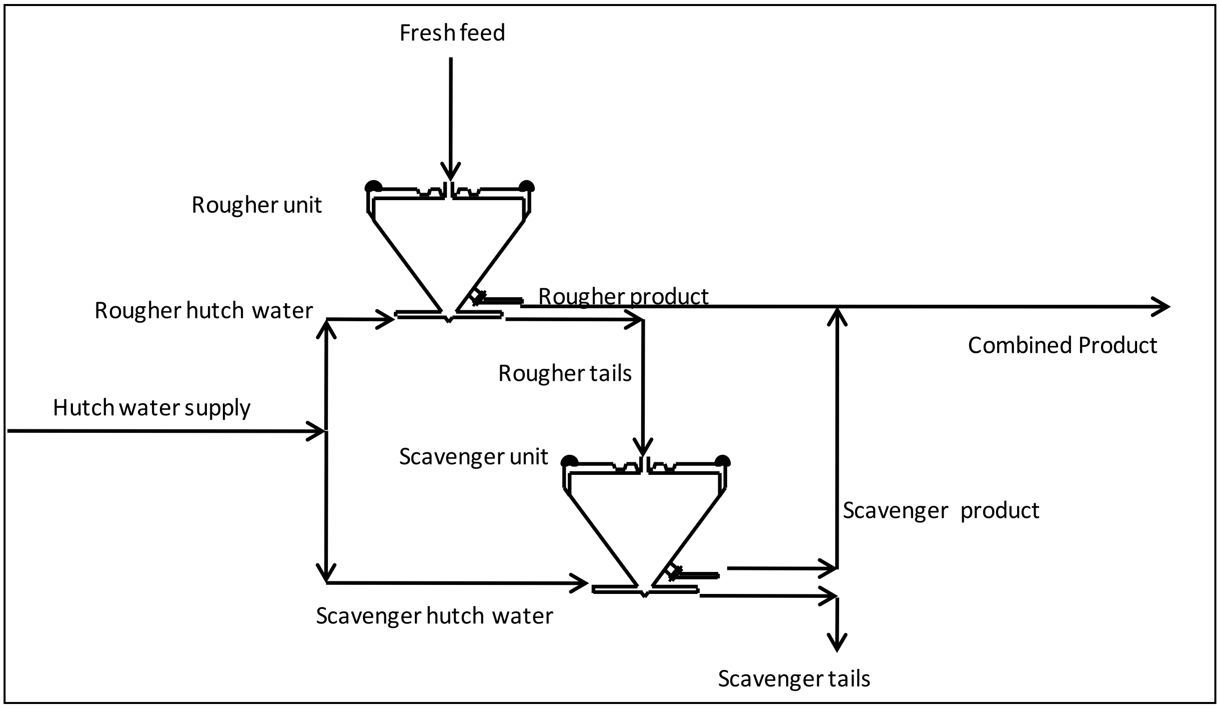


Figure 10. Schematic rougher-scavenger configuration circuit for Gekko IPJ Coal Separator

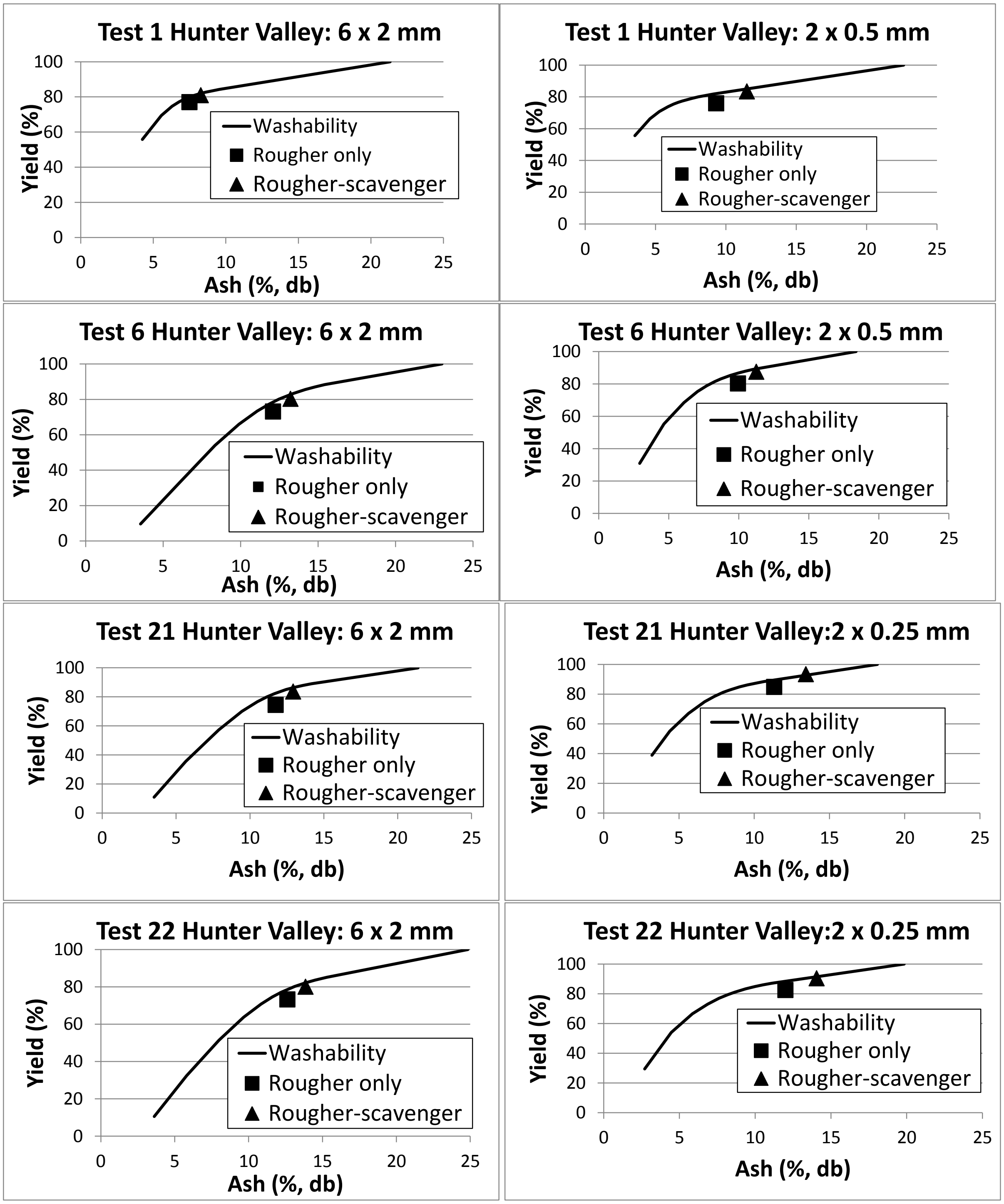
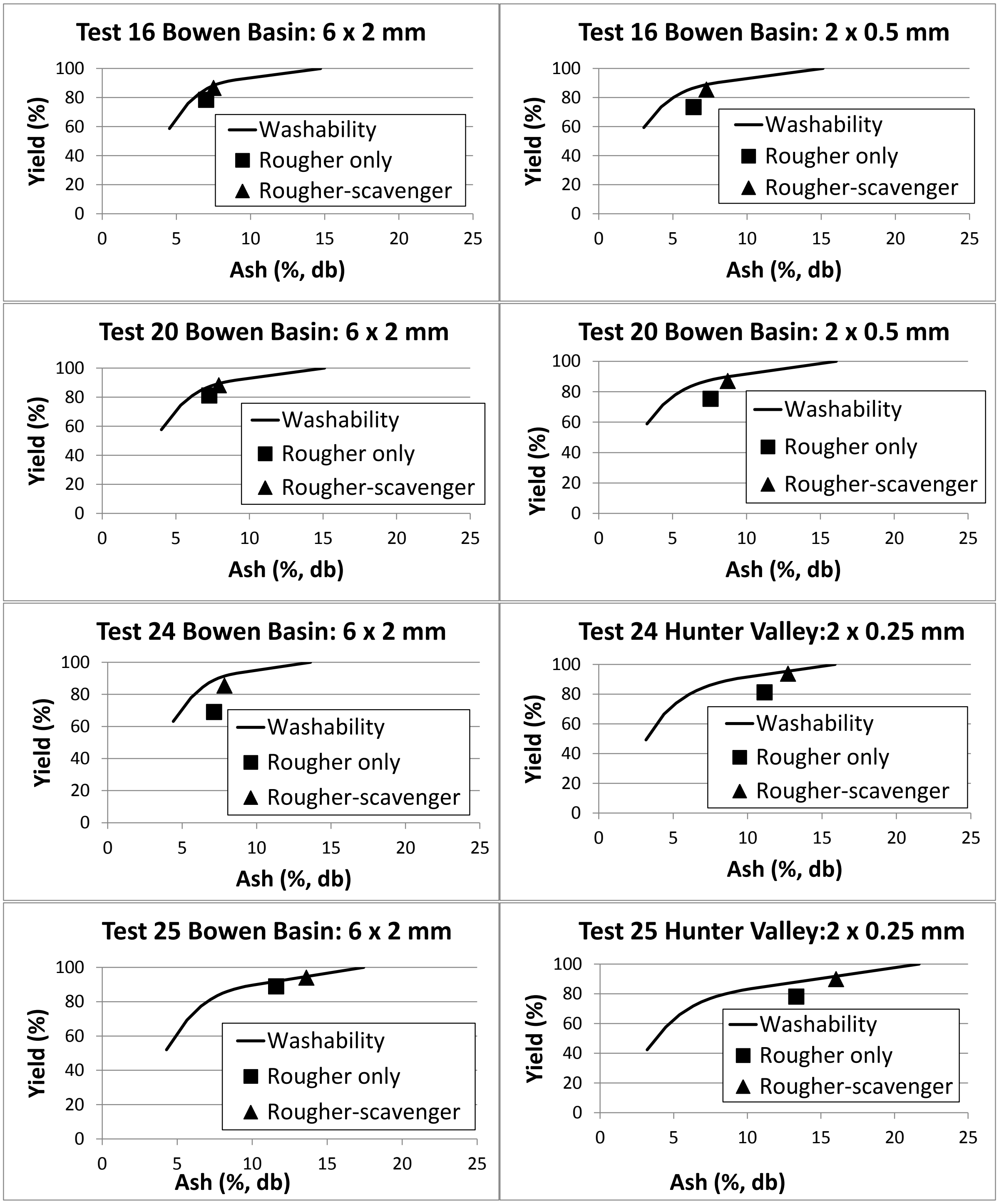


Figure 11. Measured rougher only and simulated rougher-scavenger operating points for Hunter Valley coal laboratory tests



Test 16 Bowen Basin: 6 x 2 mm

Test 16 Bowen Basin: 2 x 0.5 mm

Test 20 Bowen Basin: 6 x 2 mm

Test 20 Bowen Basin: 2 x 0.5 mm

Test 24 Bowen Basin: 6 x 2 mm

Test 24 Hunter Valley:2 x 0.25 mm

Test 25 Bowen Basin: 6 x 2 mm

Test 25 Hunter Valley:2 x 0.25 mm

Figure 12. Measured rougher only and simulated rougher-scavenger operating points for Bowen Basin coal laboratory

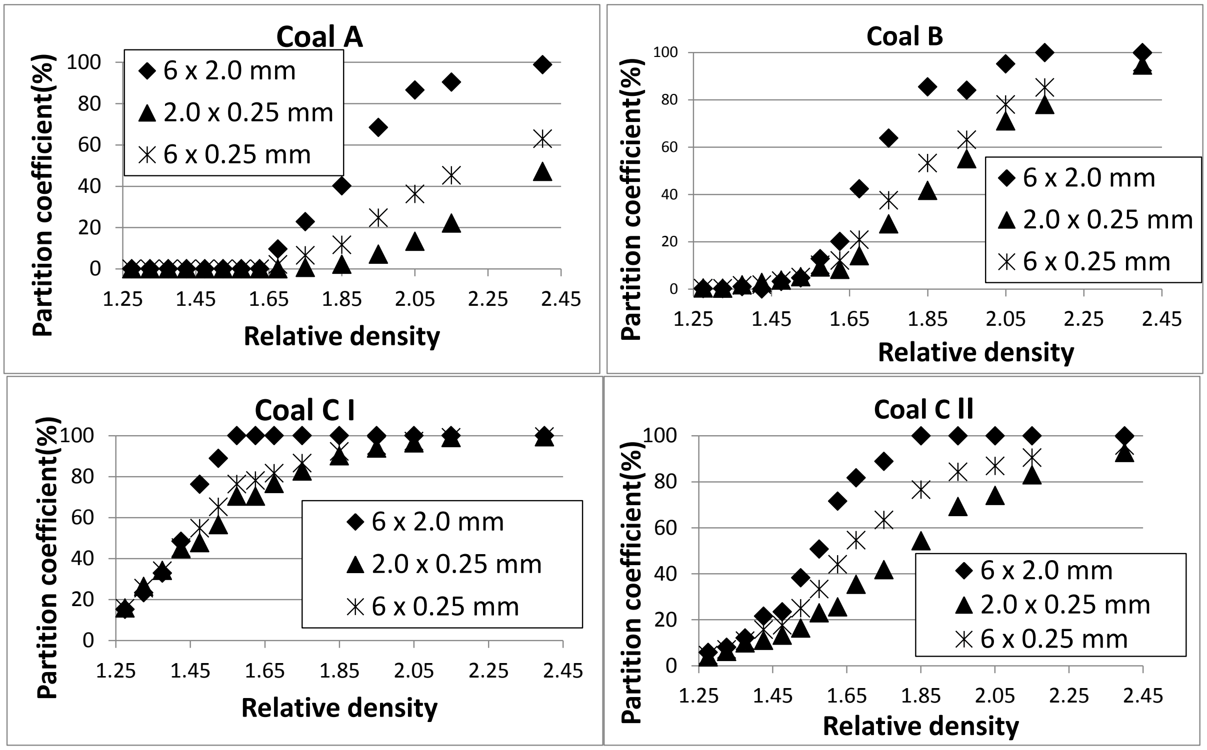


Figure 13. Partition coefficient curves for modular GICS tests with Coals A, B and C (I and II)

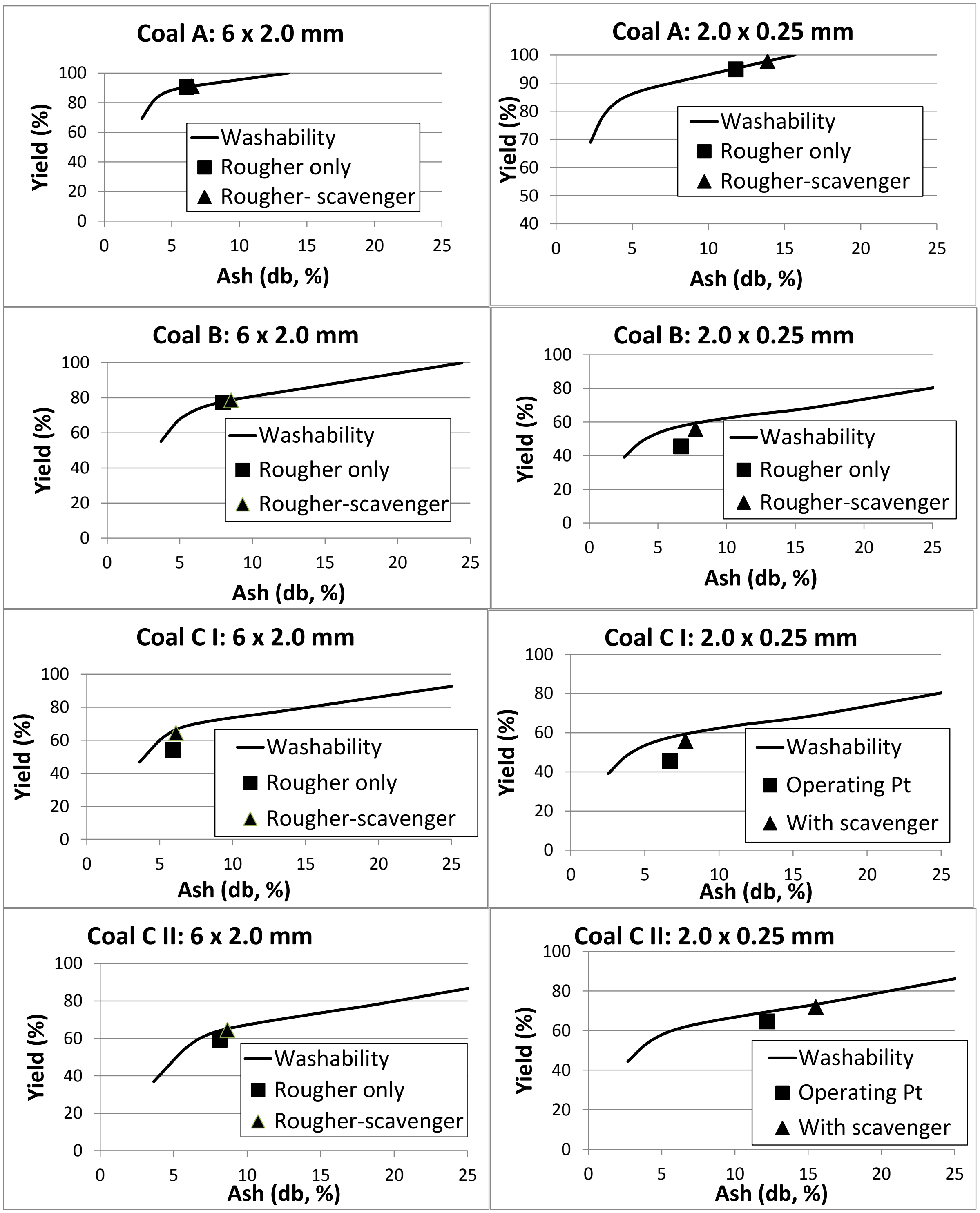


Figure 14. Modular Gekko IPJ Coal Separation performance relative to washability curves

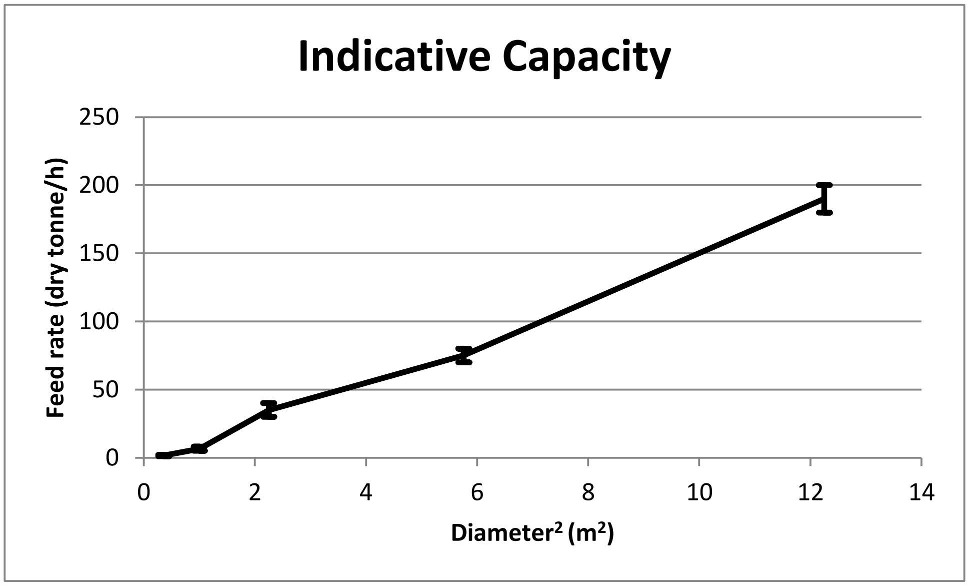


Figure 15. Indicative capacity of GICS

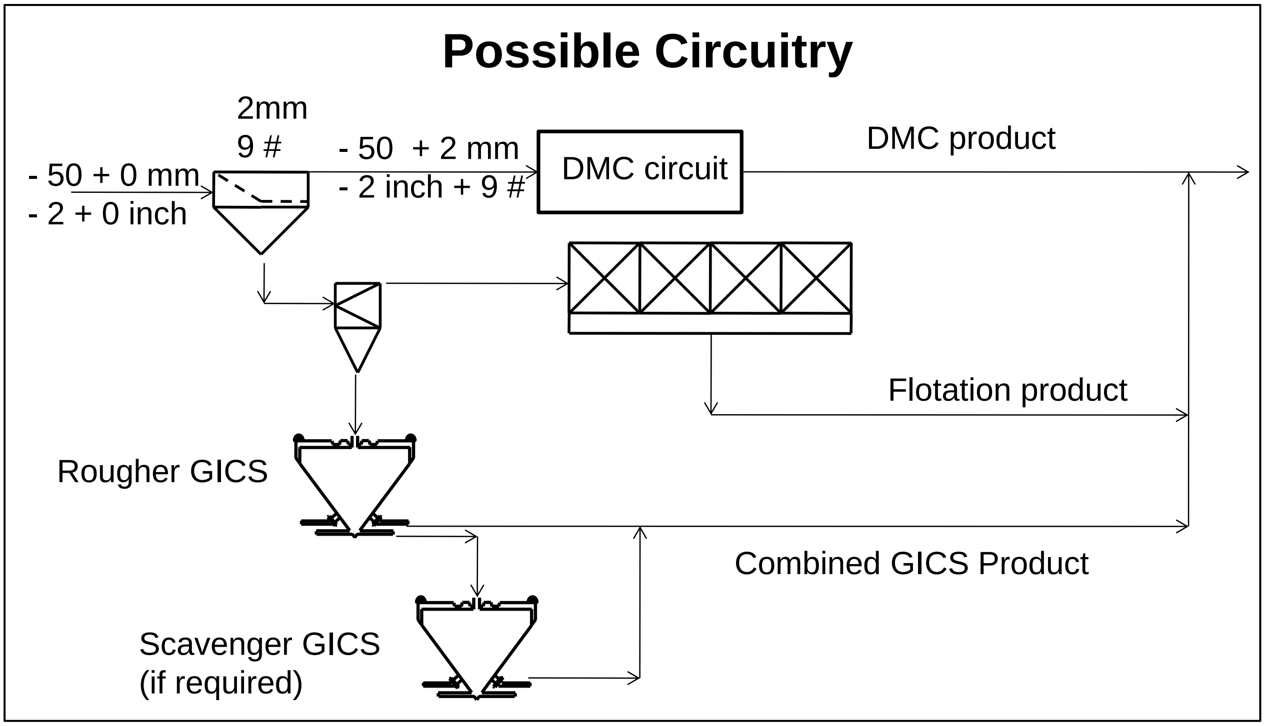


Figure 16. Schematic representation of a possible coal preparation circuit utilising a Gekko IPJ Coal Separator

Table 1. Test conditions for partition coefficient determinations

		Size	Ragging	Hutch	Reject	Pulse	Stroke	Dry	Feed %
Test	Coal	(mm)	RD	(l/s)	(l/s)	(cyc/min)	(mm)	Feed (t/h)	Solids
1	HV	- 6 + 0.5	1.6	5.1	2.7	76	10	1.03	6.1
6	HV	- 6 + 0.5	1.6	5	3.8	62	10	1.2	7.0
16	BB	- 6 + 0.5	1.6	5	2.5	62	10	0.75	4.5
20	BB	- 6 + 0.5	1.8	6	2.9	61	10	0.73	4.4
21	HV	- 6 + 0.25	1.6	5	3.4	76	10	1.12	6.7
22	HV	- 6 + 0.25	1.6	5	3.4	62	10	1.10	6.6
24	BB	- 6 + 0.25	1.6	5.1	3.4	62	10	0.92	5.6
25	BB	- 6 + 0.25	1.8	6.1	3.6	61	10	2.41	22.4

Table 2. Hunter Valley Coal D_{50} and Ep values

Test	Feed rate	- 6 + 2 mm			- 2 + 0.5 mm			- 2 + 0.25 mm		
	t/h dry	D_{50}	Ep	±0.10RD %	D_{50}	Ep	±0.10RD %	D_{50}	Ep	±0.10RD %
1	1.03	1.50	0.088	6	1.58	0.195	2			
6	1.60	1.54	0.105	20	1.66	0.180	6			
21	1.13	1.55	0.129	16				1.94	-	
22	1.12	1.55	0.129	17				1.80	0.282	

Table 3. Bowen Basin Coal D_{50} and Ep values

Test	Feed rate	-6+2 mm			-2+0.5 mm			-2+0.25 mm		
	t/h dry	D_{50}	Ep	±0.10RD %	D_{50}	Ep	±0.10RD %	D_{50}	Ep	±0.10RD %
16	0.76	1.43	0.075	23	1.475	0.200	11			
20	0.55	1.49	0.100	9	1.550	0.213	5			
24	0.94	1.50	0.150	6				2.00	-	

Table 4. Summary of test conditions

Feed		Stroke	Reject Blind	Ragging		Hutch		Product		Reject	
Type	t/h dry	Length (mm)	Cycl Orifice (mm)	RD	No of Layers	Flow Rate (m^3/h)	Press (kPa)	Flow Rate (m^3/h)	% solids	Flow Rate (m^3/h)	% solids
A	8.5	15	57	1.8	4.0	28.0	185	39.9	18.9	20.1	2.8
B	3.3	15	42	1.8	2.5	22.1	145	19.3	12.5	16.3	4.8
C I	4.5	15	42	1.6	2.5	24.5	165	21.5	12.0	19.7	8.6
C II	7.3	10	57	1.6	2.5	27.8	180	37.5	14.0	20.7	8.4

Stroke type: Saw tooth, Stroke frequency: 60 cyc/min, Product blind cyclone orifice = 25mm

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Table 5. Modular GICS D_{50} and Ep values

Coal	- 6 + 2 mm		-2+0.25 mm	
	D_{50}	Ep	D_{50}	Ep
A	1.89	0.112		
B	1.70	0.057	1.91	0.185
CI	1.43	0.069	1.49	0.172
CII	1.57	0.081	1.82	0.223

Table 6. Laboratory and Modular GICS D_{50} and Ep values

		Low Cut Point		High Cut Point	
Scale	Size (mm)	D_{50}	Ep	D_{50}	Ep
Lab	- 6 + 2	1.43 – 1.55	0.075 – 0.15		
Modular	- 6 + 2	1.43 – 1.57	0.069 – 0.081	1.70 – 1.89	0.057 – 0.112
Lab	- 2 + 0.25	1.80 – 2.00	0.282		
Modular	- 2 + 0.25	1.49	0.172	1.82 – 1.91	0.185 – 0.223

Table 7. Indicative capacities of Gekko IPJ Coal Separator

Diameter (m)	Indicative Capacity (tonne/h dry)
0.6	1 - 2
1.0	5 – 8
1.5	30 – 40
2.4	70 – 80
3.5	180 - 200