DESIGN DEVELOPMENTS OF THE JAMESON CELL

Cowburn, J [1], **Stone, R**[2], **Bourke, S**[3], **Hill, B**[4]

(1) Xstrata Technology

(2) Sedgman

(3) Rio Tinto Coal, Hail Creek Mine

(4) BHPB Mitsubishi Alliance, Riverside Mine

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Joan Ann Cowburn

Xstrata Technology, Level 2, 87 Wickham Terrace, Brisbane, QLD, 4000

Telephone (07) 3833 8569

Fax (07) 3833 8555

jcowburn@xstrata.com.au

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Cowburn, J ([1]), Stone, R ([2]), Bourke, S ([3]), Hill, B ([4])

(1) Xstrata Technology

Level 2, 87 Wickham Terrace, Brisbane, QLD 4000

(2) Sedgman Pty. Ltd.

40 Station Road, PO Box 163, Indooroopilly, QLD 4068

(3) Hail Creek Mine, Rio Tinto Coal

PO Box 212, Nebo, QLD 4742

(4) Goonyella Riverside Mine, BMA Coal

Moranbah, QLD 4744

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ABSTRACT

Since Jameson Cell flotation technology was first installed in a coal flotation application in 1988/89 at Newlands Coal Handling and Preparation Plant (CHPP) there have been fundamental improvements to its design which has led to its current status as the leading technology in Australia for fine coal flotation. These improvements, which include key hardware modifications, consist of the re-development of the orifice plate to produce considerable increase in wear life and reduction in power consumption for a given air entrainment and a significant increase in the amount of air that is entrained. Modifications to the downcomer allow maximisation of residence time and air entrainment while changes to the feed and air distribution system allows a reduction in installation cost and a reduction of solids ingress into the air line. Additionally, operational improvements such as the use of recycle to maintain constant flow to the cell feed are discussed. The recent installation at Hail Creek in the Bowen Basin, which consists of three B6000/20 Jameson Cells (6m diameter bottom-fed distributor with 20 downcomers) will be reviewed as a case study. The latest design and operability of the cells are summarised and compared against one of the original designs at Riverside CHPP also in the Bowen Basin.

JAMESON CELL OPERATION

The Jameson Cell is a high intensity flotation device, which utilises induced air as the medium for froth flotation. It was developed jointly by Mount Isa Mines and Prof. G J Jameson of the University of Newcastle in the 1980's initially treating lead slimes in the lead zinc concentrator in Mount Isa. To date there are 228 installed Jameson Cells, 94 being in coal flotation applications across the globe, 77 of which are in Australia. The principles of Jameson Cell operation have been discussed by numerous authors including Jameson et al (1988) and Evans et al (1995) and recently by Harbort et al (2003) and Harbort et al (2004) and so will not be discussed at length in this paper.

The slurry is fed to the Jameson cell slurry distributor at elevated pressure and is evenly split between the downcomers. The jet created in each downcomer by the slurry passing through the orifice promotes the inducement of air (Figure 1). The shearing action of the jet on the column of slurry within the downcomer generates fine bubbles and transports them through the mixing zone. Particles and the bubbles collide and attach to each other and subsequently travel down the downcomer through the pipe flow zone. Bubbles are removed by hydrostatic pressure from the downcomer creating a vacuum for further air entrainment. The aerated slurry exits the bottom of the downcomer and the buoyancy of the bubble/particle aggregates cause them to rise towards the froth zone. The pulp zone is principally a region of disengagement although some further collection can occur. The froth zone is the where entrained materials are removed from the froth by froth drainage and/or froth washing (Harbort et al, 2004)

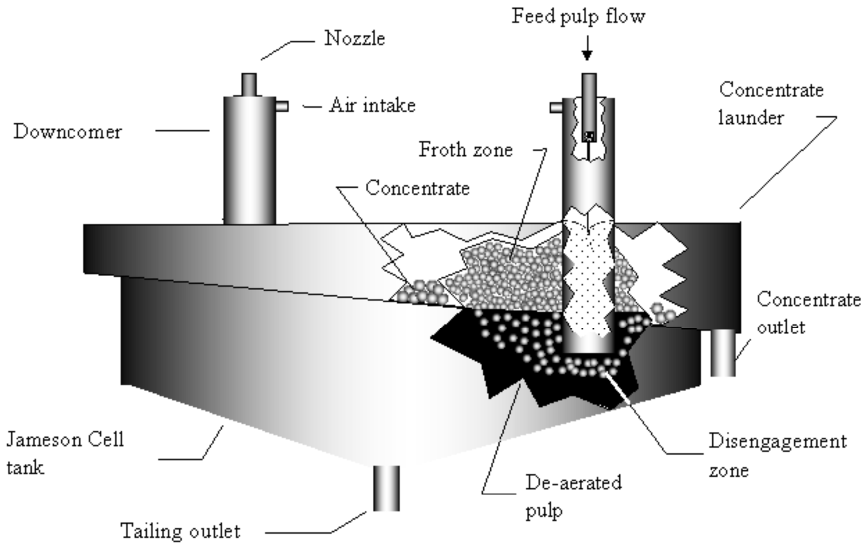


Figure 1. Schematic of Jameson Cell

JAMESON CELL INCEPTION AND DEVELOPMENT 1985-1990

In 1985 Mount Isa Mines commissioned G J Jameson to commence a project to improve the sparger design in the column cleaners in the zinc circuit. Following extensive research the concept of the downcomer was developed. The notion of co-current air and slurry direction and naturally aspirating air under a vacuum was a seldom used concept and was initially thought of as a new sparger design for a tall column (Harbort, 1992). However, further investigations showed that most bubble particle interactions took place within the high void fraction environment in the downcomer and so the collection zone of a column was unnecessary. This lead to the development of the short tank design now realised as the Jameson Cell.

In 1986 a provisional patent was lodged by G J Jameson, which was later assigned to TUNRA Ltd, University of Newcastle. Research into the technology continued with a small 2 tph pilot cell with a 100 mm downcomer and approximately 13mm orifice plate being tested at Mt Isa in the lead/zinc concentrator. In 1988 Mount Isa Mines (MIM) decided to increase the capacity of their heavy medium plant slimes flotation circuit to improve lead recovery. Investigations were undertaken into mechanical, column and

Jameson flotation cells with the latter giving the highest recoveries, which was attributed to the combination of a mineral whose hydrophobicity decreases with time and the short residence time of slurry within the Jameson Cell.

Orders were secured in 1989 for two full-scale Jameson cells for Mt Isa Pb/Zn concentrator (Harbort, 1992) and two units for the Hilton Pb/Zn concentrator.

Also in 1989, testwork was conducted at Peko Wallsend concentrator in Tennant Creek in a copper cleaning duty in an attempt to increase final concentrate grade. The test cell had a diameter of 530mm with a 102mm downcomer treating 2 tph of solids (Jameson et al, 1991). Following the test program two 1.4m diameter cells were installed in December 1989 (Harbort, 1992).

In parallel to the investigations occurring in metalliferous operations, MIM, in conjunction with G J Jameson, began trials on the settling cone overflow at Newlands Coal. The objective being to recover very fine coal: 100% passing 100 μm and a d_{50} 35 μm. Six flotation cells were installed in a two-stage arrangement. The primary units had seven 200mm downcomers while the secondary units had six downcomers. The flotation tanks were rectangular in design, each 1.5 x 3.5 m, allowing the cells to be incorporated in existing plant, and the full-scale plant was commissioned in 1988/89.

By 1990 the standard orifice plate diameter had increased to 28mm, allowing a throughput of 30 m^3/hr per downcomer. Table 1 details the modifications in downcomer diameter, orifice diameter and the consequent flow per downcomer since the inception of the Jameson Cell.

In April 1989 MIM Holdings Ltd acquired world rights from TUNRA Ltd/University of Newcastle for metallurgical purposes with TUNRA pursuing applications in wastewater treatment.

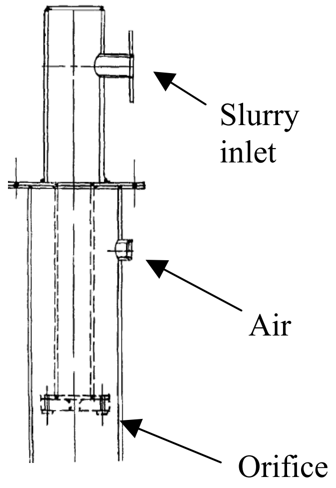
Table 1. Standard Downcomer Diameters and orifice sizes

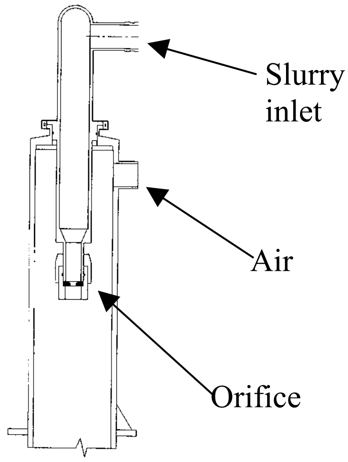
Year	Downcomer Diameter (mm)	Orifice Diameter (mm)	Flow per Downcomer (m3/hr)
1989	200	18	14
1990	200	28	30
1993	280	34	50
1997	280	38	60
1999	280	42*	75

* 42mm refers to a slurry lens design compared to an orifice plate design

DEVELOPMENT 1991-1993

The principal development during this stage of the Jameson cell early life was the downcomer, figure 2. From initial fabrication in polyurethane lined steel the design migrated into a HDPE construction with seven elements. Although this addressed the issue of weight, concerns with wear of the downcomer were experienced and so both designs were relatively short lived. Materials of construction of the orifice plate were investigated in 1991, including high chromium hardened steel and various ceramics (Harbort et al, 1994). High density Alumina was deemed to have excellent wear properties, and became the standard. The maximum Jameson Cell diameter for this period was 3.5m with 200mm diameter downcomers allowing a surface area of 8.2m^2.





DEVELOPMENT 1994-1999

During this phase many developments occurred in Jameson Cell technology, namely:

- Increase of tank diameter, downcomer diameter and so distance between downcomers
- Increase depth of tank from bottom of downcomer
- Introduction of both internal and external recycle in place of downcomer isolation
- Optimisation of bubble diffusers
- Mark 3 downcomer incorporating AISE valve and Slurry lens
- Design of the Z Cell

A few of the above will now be discussed in depth below:

Tank Diameter and Depth, Downcomer Diameter and Downcomer Distances

Design of the Jameson Cell has been driven by users directing machine development. Added to this has been very practically oriented research into fundamental behaviour by three of Australia's premier research groups, the University of Newcastle, University of Queensland/JKMRC and the Commonwealth Scientific and Industrial Research

Organisation (CSIRO). With this input, a key improvement was the increase in the maximum cell diameter, from 3.5m in 1993 to 6.5m in 2000. Parallel to this, as referred to previously in table 1, the diameter of the downcomer and the orifice diameter were also increased. Consequently, the distance between the downcomers was able to be increased thereby reducing the interaction of aerated slurry exiting neighbouring downcomers. This interaction would cause increased pulp phase turbulence that could affect overall cell recovery by causing particles recovered in the downcomer to become detached.

In terms of operation within the Jameson Cell, tank void fraction measurements show that bubble patterns in general form a central, air swept cone, as described by Taggart in 1945. The Jameson Cell tank contains areas of high, localised air void throughout the pulp zone. The rising swarm of bubbles is governed by a number of factors including recirculating patterns within the tank, pulp flow volumes and air flow volumes. Increasing the volumetric flowrate per downcomer by the above mentioned design changes may result in secondary bubble recirculation patterns within the tank, potentially resulting in attached particles becoming detached from the bubble, mineral laden bubbles being drawn into the tailing and possibly erosion of the lower portion tank structure. Resulting from a period of intense investigation the redesign of the Jameson cell took into account the increase volumetric throughput per downcomer ensuring the aerated pulp would not impact on the cell floor.

Recycle

During early Jameson Cell development it was understood that for optimum operation and plunging jet formation the device should be operated at a fixed volumetric feed rate. Due to the nature of most concentrators and coal preparation plants this was an unrealistic request and so initially in periods of reduced flow downcomers were isolated. This requires quite complex instrumentation or manual intervention and results in uneven flow across Jameson cell. This would also result in variable feed pressure and implicitly jet velocity that would affect air entrainment and reduce overall flotation performance. Consequently recycle was instigated. The Jameson cell and feed system are designed to operate at a higher volumetric throughput than the nominal fresh feed flow, with approximately 30% to 40% of the cell feed being made up of recycled tailing. In addition to stable flow to the flotation cell, this can improve recovery while not affecting concentrate quality by providing mineral misreported to tailing with another opportunity to attach to a bubble and be recovered to the concentrate launder. Additionally if cell fresh feed is lost completely the device can operate in a 100% recycle mode to act as pump protection. Recycle has now become an integral part of the Jameson cell with internal, external and detached external options available.

Bubble Diffusers

Underneath the downcomer is an area of significant turbulence and so bubble diffusers have become a feature of the Jameson cell. The design of diffuser plates has been optimised through the continuous development of the flotation device. Significant amounts of testwork has been conducted to optimise the shape, location, and porosity of the bubble diffuser. Diffusers allow uniform bubble rise velocities across the surface of the cell by slowing the superficial gas velocity in the high void faction area immediately around the downcomer. Diffusers also act to ensure even bubble dispersion thereby reducing entrainment in the froth (Harbort, 1997, internal report). The current design reduces turbulence by 69% compared to a standard downcomer with no diffuser.

Mark 3 Downcomer

The downcomer is the heart of the Jameson Cell and its design and operability are keys to the performance of the technology. Although various designs have been used for different applications and improvements introduced, the basic design remained the same for some time. A fresh approach to downcomer design has resulted in a dramatically different design that reduces the number of parts by over half and further increases the simplicity of operation of the equipment. The Mark 3 downcomer allows all parts to be located outside the downcomer, with access greatly simplified. Additionally, with the location of the slurry lens compared to the orifice plate, the effective length of the downcomer has been increased by 15%, thereby improving residence time in the mixing zone and allowing operation at higher Air-to-Pulp ratios. Laboratory scale test work has shown that the longer length in downcomer allows increased air entrainment for a given vacuum (Figure 3).

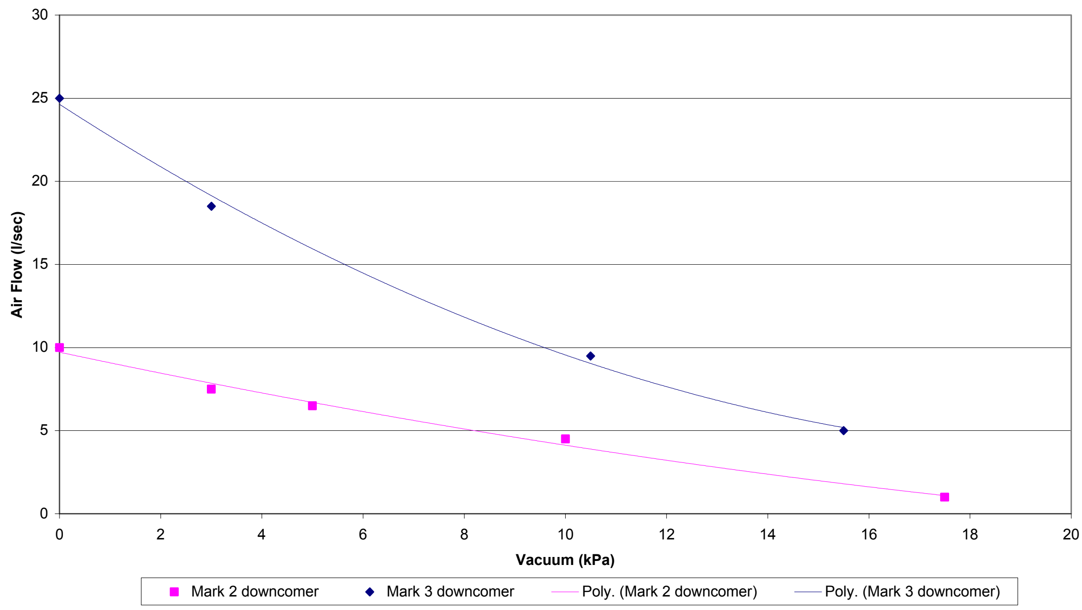


Figure 2. Relationship between Downcomer length and Induced Air Flowrate

Slurry Lens

1999 saw the replacement of the orifice plate used in the downcomer to form the plunging jet with the Slurry Lens. This was a staged development with the initial prototype being conceived in 1996 and the current design being settled in 1999. The key feature of the design is the smooth shallow entry angle (Xstrata Technology website). This ensures an optimum flow regime over the ceramic for maximum wear life. The ceramic is backed by polyurethane to cushion the impact of large heavy objects such as bolts. Even if the ceramic is damaged, the polyurethane serves to keep the ceramic serviceable.

Further benefits of the profile include:

- The ability to pass rod-like objects with greater ease, minimising blockages.

- An increase in the discharge coefficient of the orifice, decreasing power consumption by as much as 10%.
- Better jet formation with less splashing resulting in improved vacuum and air entrainment.

AISE Valve

Under normal conditions small fluctuations occur in the operation of the downcomer that results in slight changes in the vacuum. As all downcomers are connected through a common air distribution manifold, this can result in slight, momentary, movements of slurry from the downcomer into the entrance of the air system. The Air Isolating Slurry Eliminating (AISE) valve prevents this occurrence and also automatically isolates the downcomer from the air distributor when the downcomer slurry flow is isolated (figure 4). The AISE valve is a non-return check valve using the concept of a rubber curtain closing against a flat seal. The design is optimised so that minimal impedance to air flow is created whilst ensuring a rapid response to any alteration in air flow direction. The AISE valve is installed just prior to the air's entry into the downcomer at a 45° angle to allow slurry to drain back into the downcomer (Murphy et al, 2000). The use of soft rubber materials also ensures that should particles of solids be present around the valve, an effective seal will still be achieved.

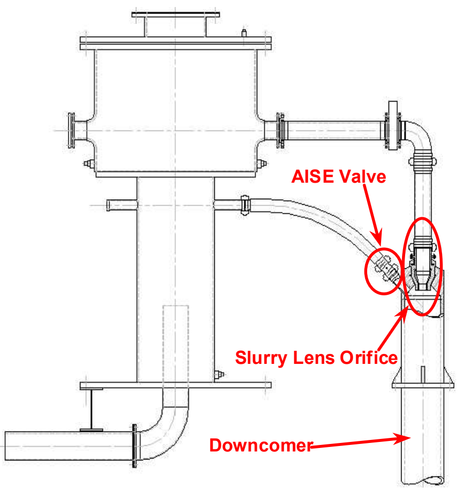


Figure 3. Schematic of Jameson cell Mark 3 Downcomer

Z-Cell

All the above mentioned features have been incorporated in the Z-Cell design, which integrates the flotation tank, feed sump and tailing recycle mechanism into a single unit that can be located on one level. Feed fluctuations are compensated internally in the cell by the hydraulic head difference between the feed and tailing boxes with no instrumentation being required. The Z-cell design is currently operating in several solvent extraction/electrowin circuits in Mexico and as a scalper in a gold operation in South Africa (Smith, 2005), see figure 5 below.

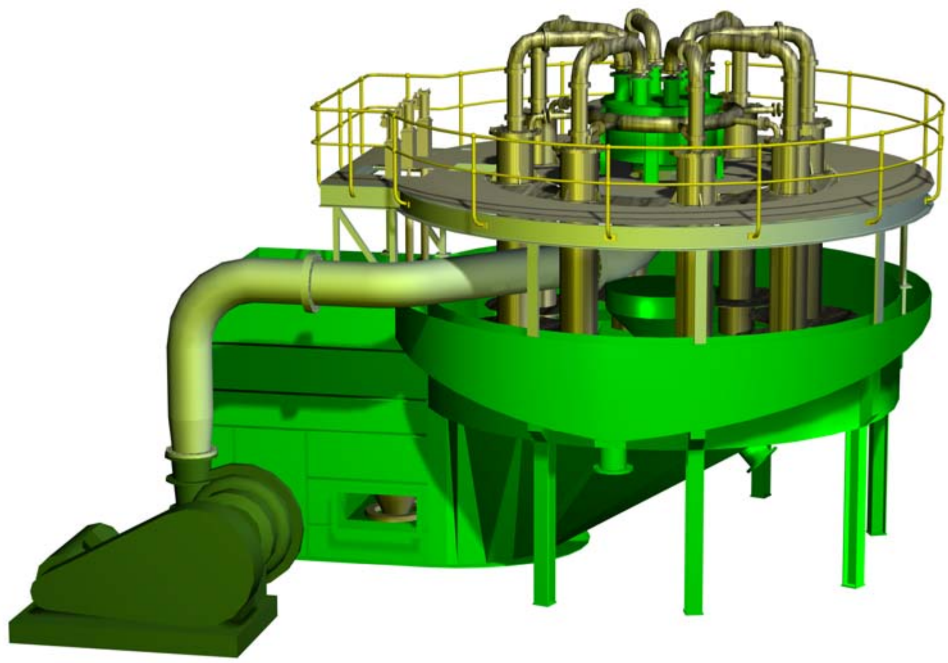


Figure 4. Schematic of Z Cell

DEVELOPMENT 2000-TO DATE

Air and Slurry Distribution

About the turn of the century design developments turned to the distribution methods of slurry and air from the single point entry to the Mark 3 downcomer. In conjunction with a leading cyclone manufacturer, Krebs, a design was developed for extruded radial slurry feed branches from the distributor to each downcomer. This modification reduced wear and also assisted in the applications of wear linings inside the slurry distributor. Also quick-release fittings were incorporated to ease any maintenance and ensure correct installation of the AISE valve.

Wash Water

For many flotation applications requiring a clean concentrate grade, wash water is an invaluable tool. Two distinct methods of wash water addition have been realised namely, above froth and in-froth. The latest design in wash water systems has been installed and operated at numerous coal preparation plants. It consists of stainless steel circular rings attached to a manual lifting system. Holes are drilled into the side of the rings to allow wash water to flow. The system can be easily located in three positions in the froth or completely above the froth. When determining the location of wash water addition (above-froth vs in-froth) the following items should be considered:

In-froth washing produces a drier concentrate, assisting in downstream filtration processes. Washing occurs closer to the froth-pulp interface allowing increased time for bubble drainage in the froth phase.

In-froth washing generally increases washing efficiency. The steady coalescence and drainage of bubbles in the froth phase leads to a wider size distribution of bubbles at the top of the froth. This can lead to channelling of water that is introduced above the froth, leading to inefficiency of froth washing. Introduction of wash water lower in the froth zone reduces this channelling.

Above froth washing results in more froth being exposed to wash water. This increased water in the froth phase acts as a lubricant to the froth, increasing mobility and decreasing bubble coalescence. These factors act together to increase froth recovery but sometimes at the cost of froth grade.

Above froth washing can lead to some froth breakage due to the impact shock of the water stream hitting the bubbles. This can lead to a decrease in froth recovery, particularly at high wash water flowrates (required for high concentrate grade operations).

Frothermiser

For decades aerosol addition of reagents has been a point of interest in flotation research although there has been little quantitative work performed until recently. Various people such as Wada et al (1968) and Flint et al (1988) published that aerosol addition of frother reduced bubble size and could lead to a reduction in frother consumption. More recently the Energy Technology division of the CSIRO compared the air and slurry phase addition methods for a pilot scale generic flotation column and a pilot scale Jameson cell (Ofori et al, 2003).

In December 2001 MIM Process Technology applied for a patent for the technology later to be marketed as the Frothermiser. The Frothermiser is an in-line device and adds aerosol frother, normally Methyl IsoButyl Carbinol, to the naturally aspirated air as it is drawn into the Jameson cell. Compressed air impacts on the liquid frother within an atomising nozzle and forms it into a mist, which is drawn into the air distributor and dispersed into the downcomers. There are two commercial installations of the Frothermiser in coal preparation plant in Australia, one in the Bowen Basin, the other in the Hunter Valley (Cowburn et al, 2005). At the time of writing no information was available on the Hunter Valley installation whereas an independent report on the Bowen Basin installation shows an increased ash on the tailing thickener underflow by 7% (Pokrajcic et al, 2004).

CASE STUDY 1- RIVERSIDE MINE

Goonyella Riverside is located 30km north of Moranbah township and 190km south west of the Hay Point port facilities. Riverside mine commenced operations in 1983 and has the capacity to produce approximately 4.0 million tonnes per annum of prime hard coking coal with Riverside coal being produced from the BHP Mitsui coal leases. This is predominantly a combination of Riverside Coke, produced from the Goonyella Lower

Seam, and Goonyella Coke, a 60/40 feed blend of Goonyella Middle Seam and Goonyella Lower Seam.

In 1989, Goonyella merged operationally with the adjoining Riverside mine, and the combined operation is known as Goonyella Riverside Mine. Following the amalgamation of the Goonyella and Riverside mines, coal sources from similar regions could be concurrently processed through both Goonyella and Riverside CPPs. Riverside underwent a significant upgrade in 1996. This upgrade saw the replacement of the conventional flotation circuit with six J5000/14 Jameson cells, arranged in single stage operation with tailings recycle, and the installation of two horizontal belt filters. These cells showed significant performance improvements over the incumbent Wemco mechanical cells and delivered yield increase in the order of 7%.

The Riverside plant processes coal utilising dense medium cyclones (DMCs) for coarse coal (nominally –50mm + 0.5mm) and Jameson Cell froth flotation for fine coal (-0.5mm w/w). The total CPP is configured as two largely independent half plants nominally treating 800tph per half plant. The half plants are further subdivided into three individual modules (i.e. six modules in total). Each module consists of a DMC circuit and a single J5000/14 Jameson Cell (Wex et al, 2004). Generally 20% to 25% of the total plant feed reports to flotation.

Within each module the fine coal feed reports to the Jameson Cell feed sump where diesel collector is added to increase hydrophobicity. The coal slurry, containing approximately 7 to 10% solids is pumped to the Jameson Cell, with MIBC as frother being added to the pump suction. The Jameson Cells are generally operated to maximise coal recovery to product whilst still maintaining a relatively low ash concentrate stream of between 5% and 6% ash.

The cells operate at feed pressures of 150kPa that equate to a jet velocity of 17.7 cm/sec. The cells operate with a recycle of between 30% and 40% of the total downcomer feed volume with the proportion of recycle being controlled by an actuated butterfly valve on an external recycle box. The level in the feed sump controls the valve position, with additional slurry overflowing the launder in the recycle box and gravitating to the tailing sump.

Reagent dosages are in the range of 8 to 14ppm of fresh feed for MIBC and 160-250 g/t diesel dependent on coal type (Wex et al, 2004). The cells have above froth washing operating at a wash water ratio of 0.8 to remove entrained gangue. Froth depths are typically run at 200mm although this may vary depending on filtration constraints as froth depth is seen to have a great affect on concentrate moisture, which has implications in the filtration circuit.

Recently further work has been progressing on the flotation cells:

In 2002 larger air intakes were fitted allowing significantly higher operating air-to-pulp ratios and also increased vacuums. This increased the superficial gas velocity (Jg) from 0.8 to around 1.5 whilst the vacuum pressure was able to be decreased from –5kPa to –10kPa. The cells now operate at air-to-pulp ratios of the order of 1.2, which has increased recovery of coal in all size fractions.

In late 2004 one of the Jameson cells was retrofitted with mark 3 downcomers. As mentioned previously the effective length of the downcomer has been increased so modifications to the length of the slurry feed pipe from the pump were made and the slurry distributor was raised (figure 6).

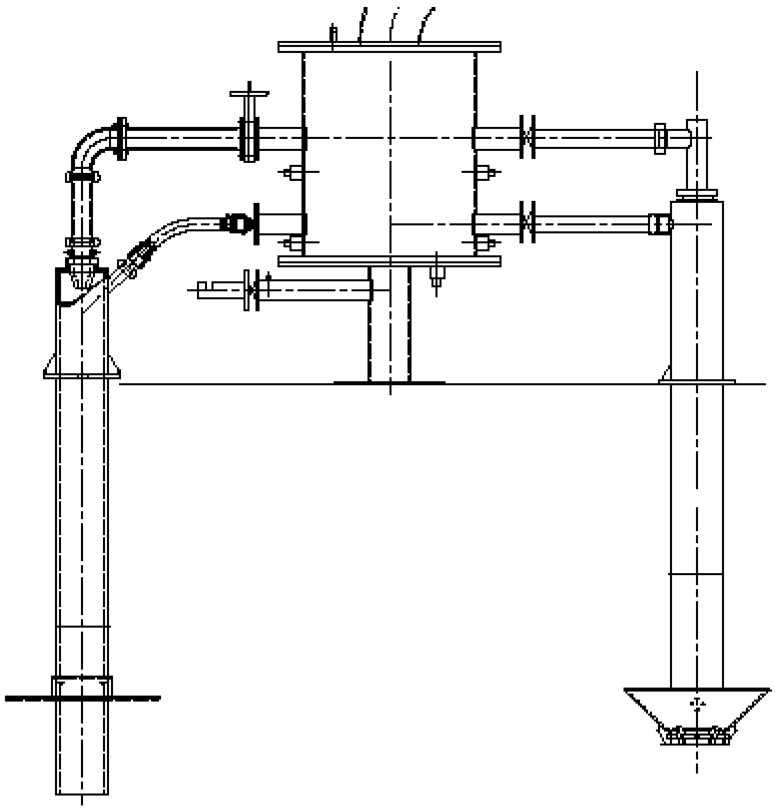


Figure 5. Schematic of Downcomer retrofit at Riverside

CASE STUDY 2- HAIL CREEK MINE

Introduction

Located 100 kilometres west of Mackay and 35 kilometres North-East of Nebo, Queensland, the Hail Creek operation produces coal from one of the world's largest coking coal deposits. Rio Tinto Coal Australia manages the operation on behalf of the joint venture interests - Rio Tinto Coal Australia (92%), Marubeni Coal (5.33%) and Sumisho Coal Development (2.67%). Hail Creek is recognised as a high quality, large-scale coal resource of some 1.2 billion tonnes with proven open cut mineable reserves in excess of 200 million tonnes. The Hail Creek coal mine has the capacity to produce 5.5 million tonnes of prime hard coking coal annually.

Plant Design

Initial testing was carried on large bore samples as this was a greenfield development. These tests confirmed that flotation would achieve targeted recovery at laboratory scale. Flowsheet development was carried out and the throughput determined from which it was decided that three cells, each six-metres in diameter with twenty downcomers would be required (Figure 7).

To simplify plant layout it was decided to use a single pump to feed the three cells. One drawback to this decision was that a non-standard impellor was required for the chosen duty. This was required to increase efficiency to bring the power draw down to match the 500 kW drive (Proud et al, 2004). During layout of the plant the sump design was changed to a tube style sump to decrease floor areas required in the plant. This led to a balance pipe configuration from the tailings deaeration sump to the flotation feed sump being used for recycle.

To counteract the migration of frother in plant water to the rest of the plant a split water system was developed. This allowed clarified water from the thickener overflow that is rich in frother to recirculate to the flotation circuit without mixing with other plant circuits.

Concentrate from the three Jameson cells was collected in open launders and flows to a distributor that feeds two horizontal belt filters. The launders were replaced with pipes when the operating level of the distributor increased above the top of the launders.

Commissioning and Optimisation

Commissioning coal for the plant was of lower quality than expected and this impacted on the initial set up of the cells. The coal was finer than expected and contained large amounts of shale. Consequently, cell operation was adjusted to handle this material and performance testing delayed until better quality coal was fed to the plant. Commissioning of the flotation feed pump was hampered by the fact the wrong impellor was supplied with the pump that caused continual overloads. When the problems were finally resolved, the required pressure was achieved at the feed distributor to the cells.

Cell optimisation was based upon achieving a concentrate that meets expected yield, although other factors such as ash content and percent solids were considered. Test work was not a reliable predictor of actual plant reagent dosage. This was due, in part, to the recirculation of frother in the plant water supply, another source of variation was conditioning time with collector. Table 2 below shows operating parameters for the three cells installed at Hail Creek.

Table 2. Operating Parameters for Hail Creek

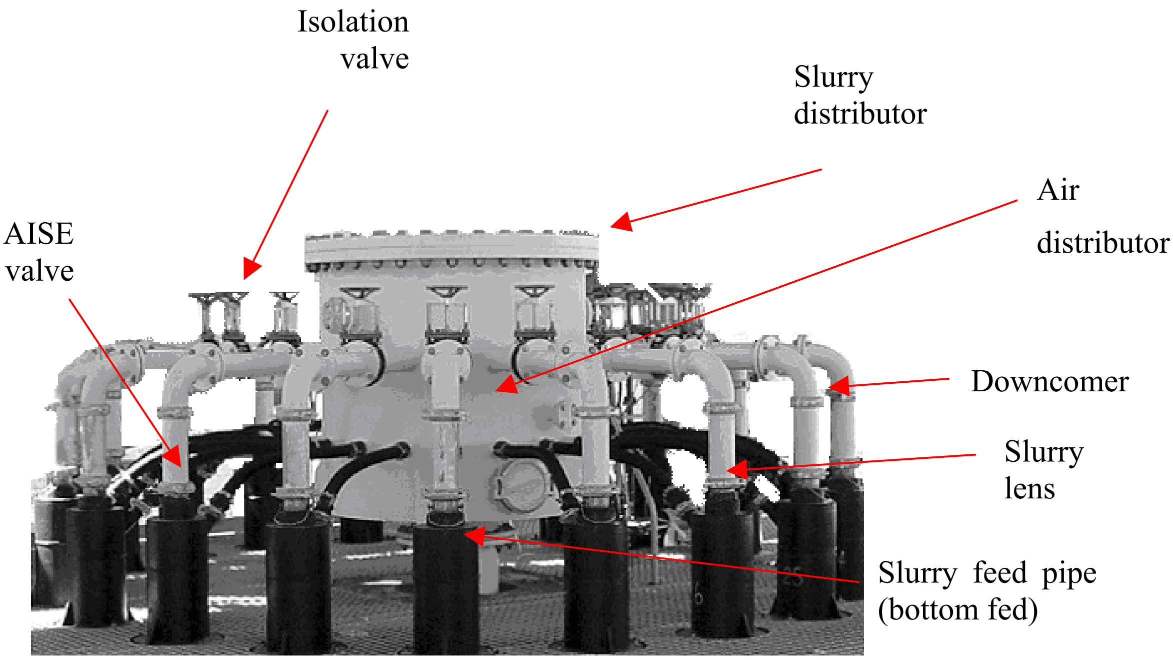
Parameter	Operating Value
Feed Pressure	150 kPa
Vacuum	-8 kPa
Air Flow	1100 m^3/hr
Froth Depth	300mm
Wash Water	78 m^3/hr
Frother (MIBC)	15.2 ppm
Collector (Diesel)	0.6 l/min

Varying levels of wash water was used to remove entrained ash from the froth, dependent on required concentrate ash. The cells at Hail Creek were designed with stainless steel concentric rings to achieve even distribution of wash water into the rising froth for submerged froth washing. Experience has shown the optimum location for the rings was just above the pulp to froth transition zone. Submerged froth washing gave good flow of clean water in the transition zone where bubbles were coalescing (Stone, 2004).

As clarified water was used as wash water it contains ultra fine particles and flocculant and had a tendency to settle in pipes that were low in velocity. In the wash water ring design, the flow around the rings had to be controlled to avoid high velocity jets from exiting the rings and disrupting the froth. Consequently, the rings contain areas of low velocity and some settling occurred. The problem was accentuated in parts by the presence of burrs from the drilling process in the rings. This settled material led to eventual blocking of large portions of the rings. The solution was to remove the burrs from the inside of the wash water rings and to provide flushing points. High pressure water was injected into the wash water manifold and opening flushing valves attached to the rings. This stream of high pressure water was sufficient to break up the settled material within about 30 minutes. The operators were instructed to repeat this operation as required (nominally weekly) with the measured flow rate to the wash water rings being used as the indicator for the timing of the flushing operation.

Water content in the froth was controlled by cell level or implicitly froth depth. A deeper froth depth will allow more time for drainage of the froth as well as removing some of the entrained high ash slimes.

As with all flotation this optimisation was not as simple as described above as there are other factors that will influence the operation of the cell. This required operators who were trained to respond to the needs of the flotation circuit. Additionally, cameras were installed in the plant allow a visual check of the operation of the cells at all times.



CONCLUSIONS

Jameson Cell development has improved performance in a number of specific areas. These include design changes to minimise wear, maximise aeration and optimise grade and recovery.

High density alumina has been incorporated into orifice plate manufacture increasing operational life. This was further enhanced with the development of the slurry lens, whose shallow entry profile has increased wear life significantly.

Modifying the feed arrangement to each downcomer, in addition to simplifying access to key components, has resulted in a 15% increase in downcomer residence time. Subsequently, for the same vacuum a higher volume of air can be induced into the downcomer.

Operation at optimal grade and recovery has been enhanced with the inclusion of components which optimise superficial gas velocity within the flotation tank.

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REFERENCES

Cowburn, J, A, Pokrajcic, Z, Harbort, G, J, Manlapig, E, V, 2005. Improving coal flotation using a new method of frother addition, in Proceeding Centenary of Flotation 2005 Symposium -in press. (The Australasian Institute of Mining and Metallurgy: Melbourne).

Evans, G, M, Atkinson, B, W, Jameson G, J, 1995. The Jameson Cell. Flotation Sci. Eng, (Ed: K A Matis), pp331-363 (Marcel Dekker: New York).

Flint, I, M, MacPhail, P, Dobby, G, S, 1988. Aerosol frother addition in column flotation. CIM Bulletin, May, pp 81-84

Harbort, G, J, 1992. Jameson Cell development and applications. Presented at AMMTEC Flotation Colloquium, Perth (Unpublished).

Harbort, G, J, Jackson B, R, Manlapig, E V, 1994. Recent Advances in Jameson Flotation Technology. Minerals Engineering Vol 7. Nos 2/3 pp 319-332.

Harbort, G, J, 1997. Internal report for MIM Process Technologies.

Harbort, G J, Manlapig, E V, DeBono, S K, 2002. A discussion of particle collection within the Jameson Cell downcomer. Trans *IMM (Section C: Mineral Process. Extr. Metall*), 111 / *Proc. Australas. Inst. Min. Metall*., 307, January/April, 2002, ppC1-C10.

Harbort, G J, Cowburn, J, A, Manlapig, E V, 2004. Recovery Interactions between the Froth Zone, Pulp Zone and Downcomer within a Jameson Cell. *Proceedings of Tenth Australian Coal Preparation Conference, ACPS, Pokolbin New South Wales,* 2004. Membrey, WB, ed. Paper C8.

Jameson, G, J, Harbort, G, Riches, N, 1991. The Development and Application of the Jameson Cell. *4th Mill Operators' Conference, Burnie, 10-14 March, AusIMM, Melbourne, pp45-50.*

Jameson, GJ, 1988. A new concept in flotation column design. Column '88 – *Proceedings of an International Symposium on Column Flotation, SME, Phoenix Arizona,* 1988. Sastry, KV, ed. pp 281-289.

Ofori, P, Firth, B, Taylor, A, 2003. Aerosol Frother Addition in Coal Flotation. *ACARP Report C11007.*

Pokrajcic, Z, Manlapig, E, S, V, Harbort, G, J, Smith, S, and Jameson, G, J, 2003. Reagent Supply apparatus for Supplying Reagent to Froth Flotation Cell e.g. Jameson Cell. *Provisional patent PO9354.*

Murphy, A, S, Honaker, R, Manlapig, E, S, V, Lee, D, J, Harbort, G, J. Breaking the Boundaries of Jameson Cell Capacity. *Proceedings of Eighth Australian Coal Preparation Conference, ACPS, Nelson Bay, New South Wales, 2000*. (Ed: Membrey, WB)

Proud, D, Lamb, R, Shooter, C, 2004. Design, Construction and Commissioning of the Hail Creek Coal Handling and Preparation Plant. *Proceedings of Tenth Australian Coal Preparation Conference, ACPS, Pokolbin New South Wales, 2004*. (Ed: Membrey, WB) Paper A1.

Smith, S, R, du Preez, P, Irons, J, Curry, D, 2005. New Frontiers for the Jameson Cell in Africa, in Proceeding Centenary of Flotation 2005 Symposium -in press. (The Australasian Institute of Mining and Metallurgy: Melbourne).

Taggart, A, F, 1945. Handbook of Mineral Dressing 12 (p120-130). (John Wiley and Sons, New York)

Wada, M, Ishchin, G, Kano, S, Nadatani, A, Suzuki, H, 1968. Experimental study on aerosol flotation. *8th Intl'n Mineral Processing Congress*. Leningrad. Paper D-8.

Wex, T, Hill, B, Meyers, A, D, Clark, L, 2004. Successes Achieved Through Incorporating Recent Developments in Jameson Cell Technology into an Existing Jameson Cell Circuit. *Proceedings of Tenth Australian Coal Preparation Conference, ACPS, Pokolbin New South Wales, 2004.* (Ed: Membrey, WB). Paper D11.

Xstrata Technology Website, www.xstratatech.com/current/t_jameson_cell_advantages _advantages