BUSTING THE MYTHS OF FLOTATION IN THE AUSTRALIAN COAL INDUSTRY

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ABSTRACT

The early 1990s saw the emergence of advanced flotation technologies such as the Jameson Cell to the Australian coal industry. Results from laboratory and pilot plant campaigns followed by full scale installations consistently proved distinct performance improvements over existing mechanical cells. These new technologies were able to produce lower ash products and high yield and recoveries in single cells (rather than banks) and a single stage of flotation. An ACARP report from the mid-1990s predicted that the industry would soon be dominated by these technologies (Sanders & Williamson, 1996).

Since its first installation in 1990 at Xstrata Coal's (now Glencore's) Newlands operation in the Bowen Basin, the Australian Coal Industry has proven to be an important breeding ground for the Jameson Cell technology allowing it to be continuously developed and improved over two decades. Now there are over 120 Jameson Cells installed in coal washing plants in Australia. Although the modern day Jameson Cells are much more robust, easier to operate, fully automated and require very little maintenance, flotation continues to be a major challenge in many operations with performance of the Jameson Cells less than optimal. However, the exact reasons for this have never been fully examined. This has led to many myths surrounding flotation, the technology used and the solutions required to solve the issues currently experienced in the industry.

This paper aims to address the common myths in the Australian coal industry which has perhaps negatively influenced the real effort that is required to address and rectify the current problems. It will explain processes that relate fundamentally to the flotation process, rather than the technology used, in order to describe the role of frothers in controlling flotation performance. It will also discuss how the term 'residual frother' has become a convenient excuse for a plant's sub-optimal flotation performance which can lead to masking of the real plant bottlenecks, and finally, the paper will examine the commonly held belief that flotation cells should always operate at the 'knee' of the ash-yield curve when in reality flotation needs to be optimised in relation to the entire washing plant and hence, consideration of gravity unit separation processes too.

Coal flotation circuits will be compared to those employed in modern base metal flowsheet designs to address the perception that the current designs used in the industry are inadequate and more sophisticated circuits should be developed. Plant data gathered from different operations will be used to demonstrate how diagnosing and addressing the real bottlenecks, rather than changing flotation technology used, or cell arrangement, is the best approach for any plant to achieve the desired flotation performance. Also of vital importance is education and training which is necessary to help plant personnel understand the fundamental flotation process and learn how to troubleshoot and respond to unwanted changes. Finally, fines circuit designs must incorporate an inherent procedure to institutionalise learnings from the errors in the past.

INTRODUCTION

By 1990 flotation was well established as an integral part of Australian coal preparation practice, although there was growing dissatisfaction among coal washing plant operations with the performance of conventional mechanical cells, the standard technology used at that time. The early 1990s saw the emergence of advanced flotation technologies such as the

Jameson Cell, which represented a major step change in process performance. The Jameson Cell was first tested and commercially installed in a coal washing plant at Xstrata Coal's (now Glencore's) Newlands mine (Jameson et al., 1991). The fines stream was cyclone overflow material which was previously discarded after thickening (minus 20-25 microns in particle size normally with ash content ranging from 15 to 40%). Pilot plant testing showed it was possible to achieve greater than 90% combustibles recovery with a product target of 10% ash and a similar moisture content value of ~10% via vacuum filtration. This led to the installation of the first generation full-scale, (so-called Mark I) Jameson Cells in 1990. Following the initial Newlands installation, many sites tested the technology which was shown to consistently produce low ash concentrates and achieve high combustibles recovery whilst being forgiving to variations in feed ash (Harbort et al., 1992; Atkinson et al., 1993; Manlapig et al., 1993). BHP Coal's (now BHP Billiton Mitsubishi Alliance - BMA) Goonyella 1,800 t/h coking coal operation in Central Queensland tested the advanced flotation technologies and subsequently replaced the entire 32 mechanical (Wemco) cell circuit with 8 Jameson Cells operating in a 2-stage configuration (Caretta et al., 1997). Figure 1 compares the performance of the Jameson Cells at this plant after commissioning to the old mechanical cell circuit. The ability of the Jameson Cell to consistently deliver a low ash product at high combustibles recoveries contributed to an overall plant yield increase of ~3.5% and led to production records at that time.

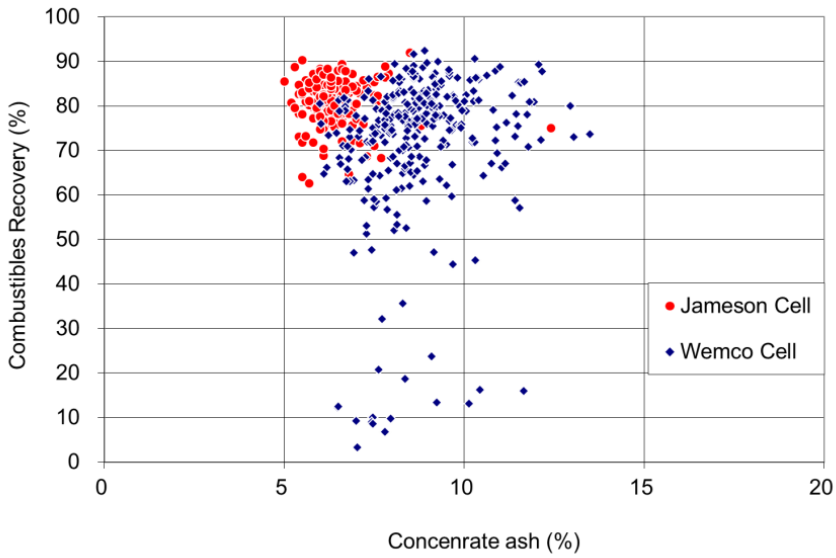

Figure 1
Full scale Jameson Cell performance at Goonyella mine compared to the original mechanical (Wemco) cell circuit

Amongst the key benefits was froth washing and the simplicity afforded by the Jameson Cell, it being easy to operate and maintain; with no moving parts, and needing no auxiliary equipment except for the feed pump. Since its first commercial installation, the Jameson Cell technology has been continuously developed and improved making it more robust and easier to use. The development of the technology can be divided into four phases, designated Mark I to IV as shown in Figure 2. There are now over 120 Jameson Cells operating in coal applications in Australia, with the current largest installation being at Wesfarmers' Curragh Mine in Central Queensland which treats over 5 million tonnes of coal fines per year using twelve cells. Some of the early installations have gone through upgrading to Mark III and IV designs targeting the benefits from such an upgrade.

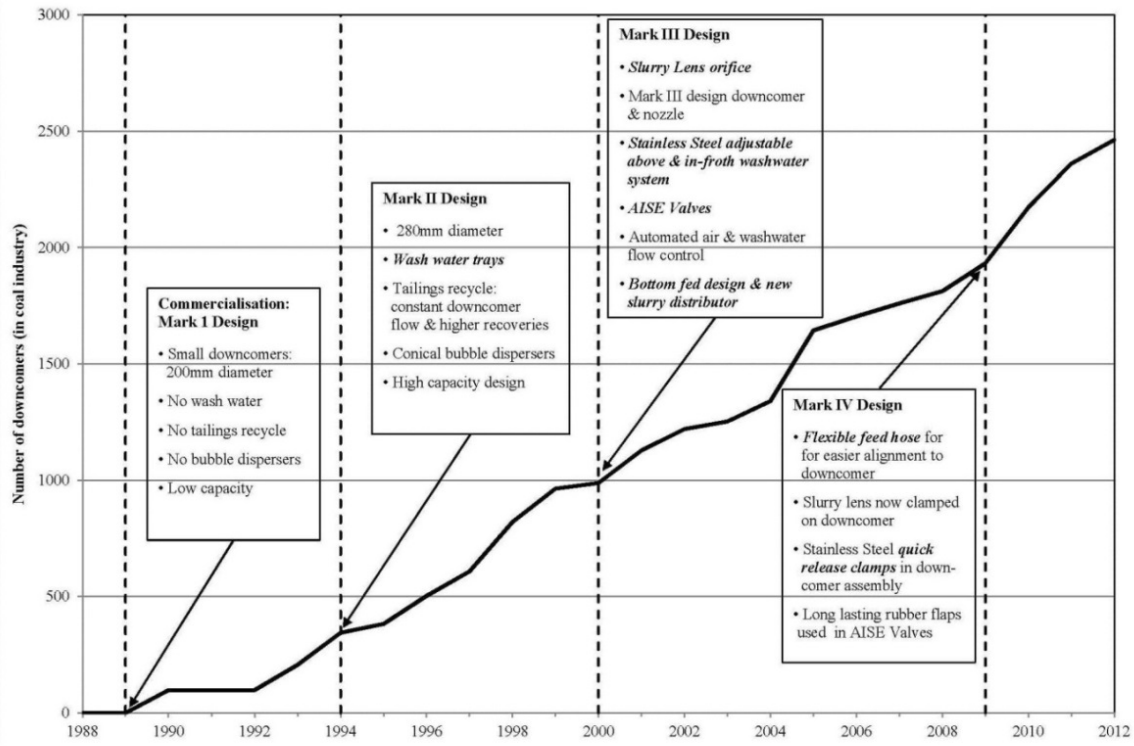

Figure 2
Jameson Cell development path

Although the modern day Jameson Cells are now much easier to operate, fully automated and requires very little maintenance, the fines circuit continues to be a major challenge, for example, with performance of the Jameson Cells being operated at less than optimal at many operations. However, the exact reasons for this have never been fully examined. This conundrum appears to have generated many myths surrounding flotation, i.e., the technology used and the solutions required to solve the real issues currently being experienced in the industry.

This paper will highlight and address five common myths in the Australian coal industry that relate to flotation. It will provide fundamental and logical explanations to hopefully dispel myths that primarily blame the technology and thereby create a more beneficial outcome by directing the focus on the real issues facing the industry today. Flotation performance data from existing sites using the Jameson Cells will be used to illustrate how plants working with the usual design constraints can rise above the 'mediocre' levels in combustibles recovery to consistently achieve high performance. Removing froth handling and downstream dewatering bottlenecks will be a key element for many plants to achieve in order for them to realise the full potential of their installed Jameson Cells. Education and training of industry personnel is also an essential need for optimising performance and creating an appreciation of the fact that chemistry factors controlled by feed characteristics and reagents are just as vital in the flotation process as the machine itself.

MYTH 1: FLOTATION IS A SEPARATE "ADD-ON" UNIT OPERATION IN THE 'BACK-END' OF A WASHPLANT

Flotation in all too many cases has been the last process to appear in a washing plant, either conceptually or as a retrofit in plants already built and operating. This has been mainly due to the "installed cost vs. apparent benefits" argument, and the resultant operation has invariably underperformed against expectations. The main reasons for this can be simply categorised as having been one or more of the following; poor design, inadequate design data, poor equipment selection and “cutting corners” or cost saving measures prior to the final sign-off and installation.

A washing plant consists of three main circuits which treat coal of different a particle size range. For example, the modern day washing plants in Australia usually have a coarse (50x1.5mm), intermediate (1.5x0.25mm) and fines (0.25x0mm) circuits. The coarse and the intermediate circuits which typically account for 70-80% of the throughput, use gravity-based separation techniques to produce their product components. Gravity methods become increasingly inefficient as the feed gets finer, and the magnitude and nature of this deterioration is well known and often predictable. However, flotation, an entirely different separation technique which is surface chemistry based is a very different proposition. There are no Ep’s for flotation equipment and their performance must be determined by test work. Although the fines circuits treat a much smaller proportion of the raw coal feed compared to the gravity circuits, it can still play a vital role in controlling the overall product quality from the plant. It can usually be manipulated to enable optimisation of the overall yield of the overall plant for the specified quality of the combined product.

In many plants, operators tend to optimise the gravity and flotation circuits separately often overlooking the fact that there is only a single product produced from the plant. In actual fact, this product is composed of perhaps 3 or 4 components which emanate from circuits having differing control capabilities. So a flotation component needs to be integrated into an overall operating strategy to achieve the desired plant yield and product quality.

MYTH 2: FOR OPTIMUM FLOTATION PERFORMANCE, FROTHER CONCENTRATION MUST BE ABOVE 15 PPM (THE ‘MAGIC NUMBER’) AS IMPOSED BY THE FLOTATION TECHNOLOGY VENDOR

Due to the very high yields (mass pull) often encountered in fine coal flotation, there must be sufficient bubble surface area to enable the capture and recovery all the required coal particles. This is particularly so in the treatment of coking coals where up to 80-90% of the feed mass reports to the concentrate, machines that can produce a large number of very small air bubbles (small mean size) are therefore advantageous because for the same volume of air, more individual bubbles are generated representing vast bubble surface area, i.e. carrying capacity. Large carrying capacity means higher productivity than other machines which generate larger bubbles (large mean size). The Jameson Cell is able to produce ultra-fine bubbles via by the shear action of a plunging jet (Evans, Jameson & Atkinson, 1992). Air bubble mass generated lies in the range of 300 to 700 μm (Sauter mean diameter, D_{32}) (Evans, Atkinson & Jameson, 1993).

Frothers are required in the flotation process to prevent air bubbles from coalescing. Regardless of the technology used, frothers should be used at dosages above the critical concentration of coalescence (CCC), as this is the minimum concentration required to prevent coalescence (Cho & Laskowski, 2002; Finch, Nesset & Acuna, 2008). The graph in Figure 3 shows bubble size as a function of frother concentration for the commonly used MIBC (methyl isobutyl carbinol) using the Jameson Cell and a mechanical cell. The CCC is a property of the frother and independent on the machine used as clearly shown in Figure 3. The CCC is measured to be 15 ppm for MIBC. However, the machine dictates the minimum bubble size generated and the figure clearly illustrates that the Jameson Cell produces significantly smaller bubbles than the mechanical cell. This dispels the myth that a ‘magic number’ is imposed by a flotation machine vendor to make their machines ‘work’, as often implied. The inability to add sufficient frother due to any inherent design problems, or plant bottlenecks will affect ALL flotation machines without prejudice, and hence also similarly affect carrying capacity. So even at concentrations below the CCC, the Jameson Cell will generate smaller bubbles and hence, have greater potential carrying capacity than most other machines. If a plant operator wishes to change the type of frother they are using, they would need to take into account the CCC characteristic of the potential replacement and review dosages on a fair and comparable basis. The frother reagent supplier should be able to provide this information for customers.

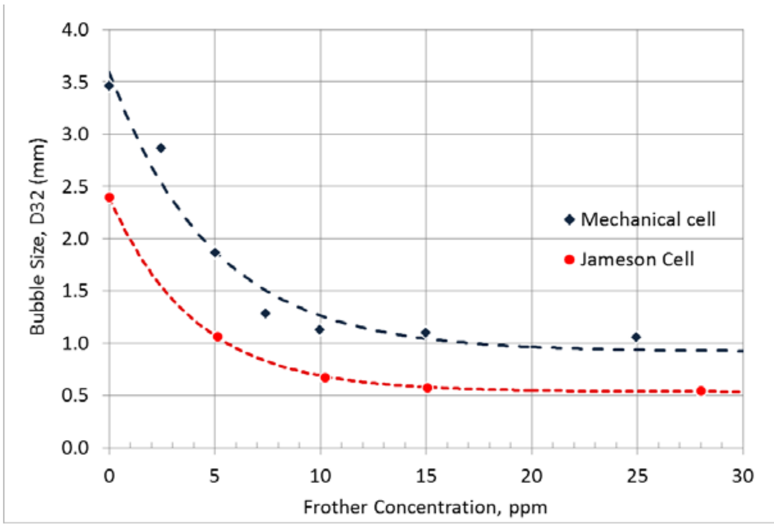

Figure 3
Bubble size as a function of frother concentration

MYTH 3: 'RESIDUAL' FROTHER PROBLEMS IS LIMITING FROTHER DOSAGE

Low yield of low combustibles recovery from the Jameson Cell can be attributed to insufficient frother addition (below that required for the CCC), which decreases the carrying capacity of the machines. Without truly understanding the real issues at individual sites, operators nowadays appear to have developed an exaggerated fear of 'frothing out the plant' which all-too-often causes them to automatically reduce the frother dosage. 'Residual' frother is defined in this paper to mean frother remaining in the water exiting the fines circuit either via the flotation concentrate, or tailings streams. This water then gets recirculated and used in other areas of the washing plant. This can compromise the performance of other unit operations such as the dense medium cyclone circuit, as 'residual' frother can cause frothing in sumps, pumping issues and affect density gauge readings etc. Its effect on a plant is largely dependent on the design of the water circuit. A site where the water recirculates around the plant quickly tends to have more issues because the build-up of frother concentration is faster than its decomposition or break-down. However, it has been found that in reality, 'residual' frother is not always the first, nor the primary, culprit for operators to 'turn-down' the frother dosage. Instead, it may be caused by a number of other issues within the fines circuit itself. Common contributors are a number of dewatering issues occurring downstream of the flotation stage. Examples include; using frother dosage as a way of deliberately decreasing the tonnage and volume produced from the Jameson Cells, e.g., to try to avoid a 'sloppy concentrate' in the case of horizontal belt filters (HBF); or motor trips, in the case of screen bowl centrifuges (SBC). Essentially, the dewatering process is controlling the separation process which is far from an ideal situation.

In recent years, SBCs seem to have gained in popularity compared to HBFs, probably due to their smaller footprint and lower installed capital cost. However, their suitability for dewatering high quality Bowen Basin type coking coals is debatable as SBCs cannot capture material less than 45 micron, which is consequently discarded with the tailings. Unlike some Australian thermal coals which may have higher ash in the finest fractions due to clay material, coking coals usually has high vitrinite in this size fraction as coal macerals tend to be friable and therefore highly concentrated in the raw coal fines. But plants employing SBC's are often left with what is installed due to the anticipated cost of retrofitting a more effective solution. Disposal of the effluent is normally via the tailings thickener but as this stream is extremely frothy (stabilised by fine hydrophobic coal particles) there are always pumping issues due to inadequate design of sump and pumps. At too many plants with SBC's, effluent spillage is a primary reason to 'de-rate' the flotation recovery. As expected, the effluent stream is high in frother concentration and yet, it is designed to exit the fines circuit whereas for plants where HBFs are used, the filtrate is returned to the flotation feed as a means of minimising 'residual' frother effects. Although it is far from ideal not to capture the minus 45 micron coal-rich fines fraction, it is still advisable to return the centrate to the SBC feed rather than the flotation feed. Some plants have introduced this practise thereby avoiding the inevitable build-up of a circulating load of fines in the flotation circuit. It clearly makes no sense to continually return coal fines already recovered back to the separation process despite the original poor choice of dewatering technology for the feed type. Clearly, the selection procedure for the dewatering technology needs to carefully consider the particle size and type of coal treated and not use capital and/or operating cost as the main decision driver.

Generally, poor design of the overall fines circuit appears to be the main culprit for sub-optimal flotation recovery at many sites. Improvement must be made in the design of sumps to handle large fluctuations in froth volumes, and appropriate pumps installed to transfer frothy streams. Dewatering units like SBCs, which are sensitive to flows, may benefit from a buffer tank upstream or more appropriately a coal thickener, which not only reduces the volume but increases the solids content that is to be treated.

The challenges experienced at individual sites are not always the same and proper diagnosis is the key to addressing the right issues at each operation. A review of all the Jameson Cell installations in Australia shows the bottlenecks can be, in general, placed into one of 3 categories. These are education, measuring and/or addressing minor design issues (30%), concentrate dewatering capacity and/or issues (60%) and flotation capacity issues (10%). This shows that the majority of sites do not actually have a problem with the Jameson Cells, highlighting the need to focus on addressing the fundamental issues rather than just the flotation machine. That is why any debate directed towards solving current industry issues by swapping the flotation technology used (as discussed later in Myth 5), is perhaps premature if not mistaken. Only Category 3 relates to the flotation machine, but this is due to inadequate flotation capacity. It does not imply that the Jameson Cell will perform poorly when treating the feed for which it was originally designed.

MYTH 4: THE ADVANCED FLOTATION TECHNOLOGIES SUCH AS THE JAMESON CELL 'ARE NOT WHAT THEY ARE CRACKED UP TO BE' AND 'PERFORM POORLY' AS DESIGNED

The Australian Coal Industry was rapid in its adoption of the Jameson Cell soon after its commercialisation in 1989, thereby significantly contributing to its eventual wider adoption and growth over a period of only two decades. The latest model (Mark IV design) of Jameson Cell is therefore a great improvement over the first generation of Jameson Cells. Currently, typical duties are far less demanding as the raw coal fines feed tends to be coarser (than the original Newlands circuit) and together with the improvements made to the technology, it would reasonable to expect the Jameson Cell would be much more robust and perform at least equal, if not better, than in earlier installations. However, there is a perception in the industry, particularly in recent years, that once installed the Jameson Cell technology often 'performs poorly'. This is most often undefined and does not specify or quantify why the Jameson Cell cannot achieve expected values of concentrate ash, yield/combustibles recovery or either. In fact, Xstrata Technology believes that the exact reasons for 'sub-optimal' flotation performance in many operating plants have never been properly investigated.

The key to optimising flotation is firstly, to understand that it is a complex multifaceted separation process that is driven by surface chemistry and not by gravity like the other unit operations in a coal washing plant. It is controlled by three main factors that in turn can be categorised into three areas: the coal, the chemistry and the machine as shown below in Figure 4.

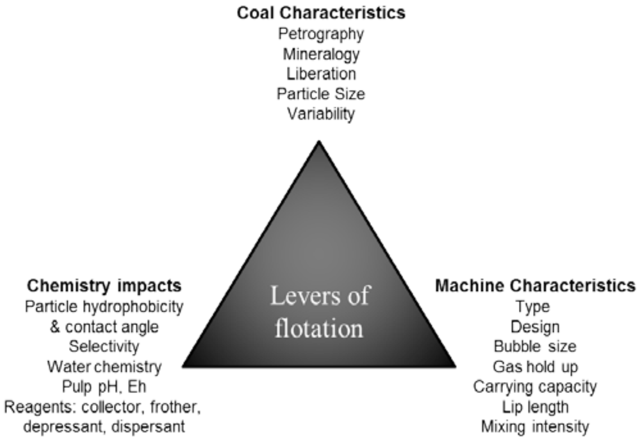

Figure 4
Flotation 'triangle' showing the key factors affecting performance

The flotation machine is one of three facets important to the overall process, but seems to get the most attention and is often blamed when flotation performance is poor. However, the variability of the coal and flotation reagent control are two equally significant factors, relating to the other facets of the triangle, and both are perhaps surprisingly, often overlooked. The greater the number of different coal seams and sources that are treated, the more challenging is the task of achieving effective flotation and meeting the targeted qualities and recoveries. Plant designers must therefore take into account all factors that are going to be influential in ensuring expectations are met. Plant operators must be properly trained to fully understand how the circuit is intended to perform and then be able to respond appropriately. This includes the correct response to changes in tonnage, particle size distribution and flotation behaviour of the different coal types by making the necessary adjustments to reagent dosages and process variables to ensure optimised performance.

In many plants, monitoring of flotation performance is irregular and often a 'knee-jerk' or spontaneous change is made when performance has clearly deteriorated. Furthermore, it may be impossible to conduct sample surveys via the feed, concentrate and tailings because sample points do not exist. Even in the more modern (recently built) plants, the flotation feed often cannot be easily collected as it usually consists of more than one stream which gravity flows into a large collecting sump. In many Jameson Cell installations, operations personnel unknowingly collect the downcomer feed and use the ash result from this stream in the two-product formula to calculate yield and combustibles recovery. This is then erroneous as the downcomer feed is in fact an internal stream. The correct and incorrect streams to collect around the flotation circuit are clearly illustrated below in Figure 5.

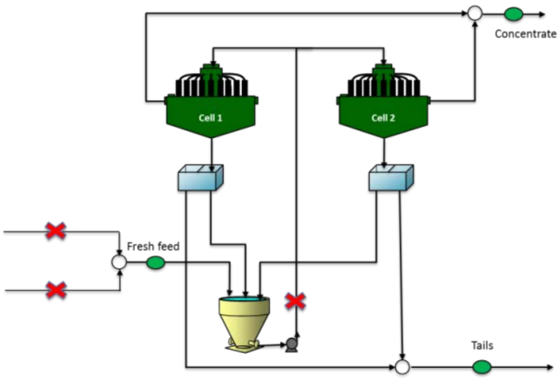

Figure 5
The correct (green circles) and incorrect (red crosses) sample collection streams for flotation surveys

Regular flotation surveys are necessary for measuring and gauging performance. Results need to be plotted as an ash-yield curve and benchmarked against a characterisation curve for each coal type treated. Figure 6 shows six months of plant data from an existing operation (Plant A). A wide range of combustibles recovery values is shown and at ash values which generally lie on or around the characterisation curve. This is typical for a Jameson Cell circuit, in either single or two-stage configurations. But this result may not be achieved using other flotation technologies machines. For example, mechanical cells are likely to produce higher ash concentrates, when used in the same configuration because this type of machine is less selective and commonly does not employ froth washing. As a consequence the data points obtained will lie to the right-hand side of the characterisation curve. The large variation in the combustibles recovery shown in Figure 6 means that high recoveries are possible (i.e., the Jameson Cell itself is not the problem) but the process has not been properly optimised. Knowing this, Plant A needs to diagnose then address the real issues with the aim of reducing the variation to consistently achieve the desired target for combustibles recovery.

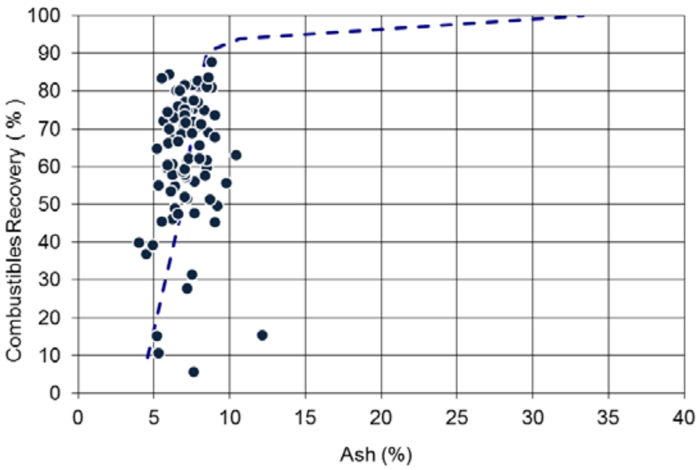

Figure 6
Plant data from Plant A benchmarked against the characterisation curve

Figure 7 shows performance data from another operating coal preparation plant (Plant B). This plant when compared to Plant A, has reached the next stage of flotation optimisation. Clearly, the data points are centred around 5 to 7% ash (i.e., achieving the set target) at combustibles recovery values of around 70 to 90%. Plant B operates with many design constraints just like other plants, but this operation has obviously implemented effective strategies for dealing with these issues and is operating within these limitations.

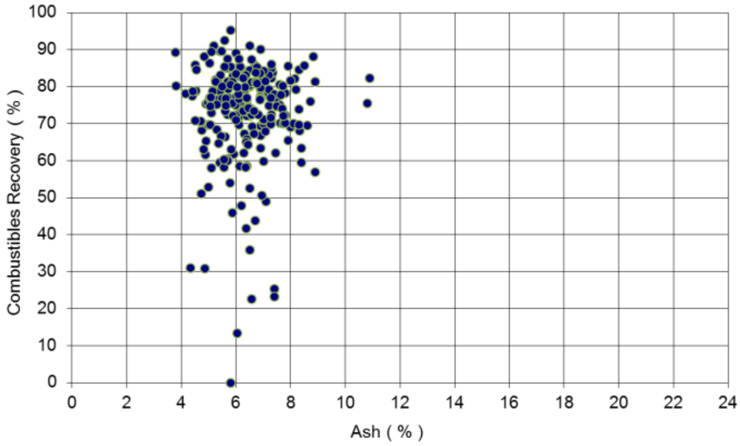

Figure 7
Plant data from Plant B

Figure 8 shows the performance data from a third preparation plant, Plant C. This operation has focussed on eliminating the major bottleneck which has been downstream concentrate dewatering. This is a good example whereby the Jameson Cells are unaffected by extraneous factors and can be operated as designed to realise the full potential.

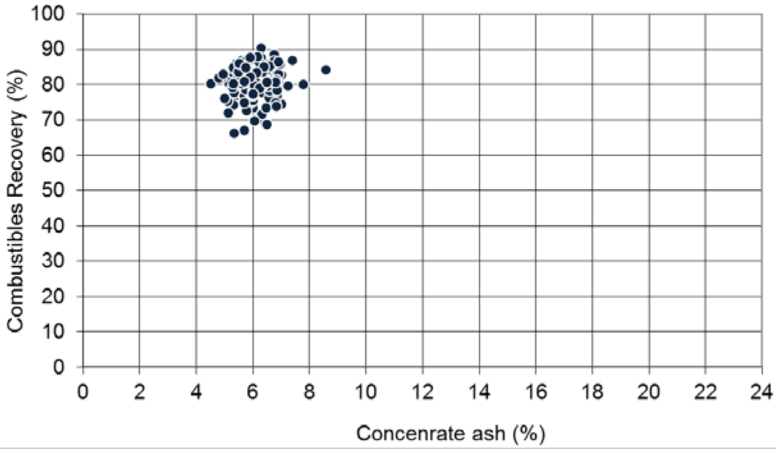

Figure 8
Plant data from Plant C.

The flotation performance of all three different sites were graphed using data collected from six months of shift or daily samples, all during 2013. The results obtained should clearly dispel the myth that the flotation machine is the problem and counter speculation that the Jameson Cells perform badly 'as designed'. Instead, this highlights the importance of sampling and regular monitoring, understanding the flotation principles (the flotation triangle) and diagnosing the real plant issues. The Jameson Cell is not a stand-alone piece of equipment. To be fully utilised it has to be integrated into fines circuit design that allows it to be used to its full potential for all types of feed.

MYTH 5: THE AUSTRALIAN COAL INDUSTRY SHOULD CONSIDER A RETURN TO MECHANICAL CELLS AND DESIGN COAL CIRCUITS SIMILAR TO BASE METALS INDUSTRY

In recent times, a body of opinion has emerged that is suggesting that perhaps the Australian Coal Industry may be better served by reverting to using mechanical cells to treat raw coal fines. This is possibly driven by a misconception that Jameson Cells, and columns, have in some cases been the root cause of below par performance and resultant low yields/combustibles recovery, i.e., loss of coal to tailings. It may be easier to blame the technology, but this is clearly not the primary cause. Re-adopting a conventional technology that has been superseded by more advanced ones will not help the industry to address the underlying issues or identifying the true cause. To achieve this requires a rigorous diagnostic approach followed by progressive debottlenecking of the fines circuit that have been shown to be preventing the installed cells from being fully utilised. With a clean sheet of paper the design of new fines circuits must overcome current and/or old issues and be better integrated into the overall plant. In this regard, properly structured teaching and training of operations and maintenance personnel will ensure a better understanding of the basic principles of flotation and the capabilities of the flotation circuit as a whole. The key reward will be the confident performance of operators, and valuable know-how generated for plant designers and consultants.

The current design and operational issues, all too frequently encountered in the fines circuits have perhaps detracted from the realised benefits that the advanced flotation technologies have provided the Australian Coal Industry. For the Jameson Cell, the most noticeable of these are the high quality concentrates that can be produced, the small footprint and very low maintenance requirements. It is difficult to understand how a return to mechanical cells would be at all advantageous as conventional technologies are simply less effective in treating coking coal deposits in Australia. For example, a mechanical cell circuit will not be able to achieve a comparable high yield and combustible recovery at the lowest ash content. Add to this the footprint and the high maintenance due to moving parts (rotors), motors and blowers and the benefits swing even more towards the more advanced technology. However, this swing has not yet been as strong in other coal producing countries around the world. Countries like India and Russia have been slower to change and are only beginning to realise the benefits of adopting advanced technologies over the conventional cells which they have been using as standard for decades. In contrast, new coal producing regions such as Mongolia and Mozambique already use the advanced flotation technologies as standard in design of their new washing plants.

Across the many differing types of industries utilising flotation, the momentum has shifted towards advanced technologies in favour of conventional cells. In particular, the Jameson Cell technology is successfully used in a number of different industries to address plant issues and/or improve plant performance. In the metals industry where flotation is the dominant separation process, the mining of more complex ore-bodies and decreasing metal head grades means the standard flotation circuit traditionally utilising all mechanical cells, can no longer achieve the desired performance. Inclusion of Jameson Cells into conventional cleaner circuits is necessary to produce clean saleable concentrates that are sufficiently low in non-sulfide and silicate gangue, penalty elements (such as fluorine and mercury) or deleterious elements such as Uranium (Araya et al., 2013). Other examples include the phosphate industry where a method was developed to recover ultrafine phosphate that had until that time been long considered as unrecoverable in this industry (Teague & Lollback, 2012) and another good example is the use of the Jameson Cell to enhance the recovery of bitumen in the oils sands industry (Neiman et al, 2012).

Regardless of industry and application, flotation circuits should always be of the simplest and most robust design to achieve the desired product quality and recovery. Feed characteristics and the degree of upgrade desired will dictate the number of stages required to achieve the desired performance. For example, base metal flotation often requires multiple stages to sequentially upgrade the very low grade feed to an acceptable final product quality. The mass passing to the final concentrate (equivalent of yield) is always very low in comparison to coal and typically no higher than 10%.

Figure 9 shows an example of a flow sheet designed to treat copper ores which consists of rougher and scavenger stages followed by three stages of cleaning. In contrast, the upgrade required in coal applications is very low and can be easily achieved in a single step so the circuits can be much simpler, as shown in Figure 10. Circuits for coal treatment only typically require single or two-stages.

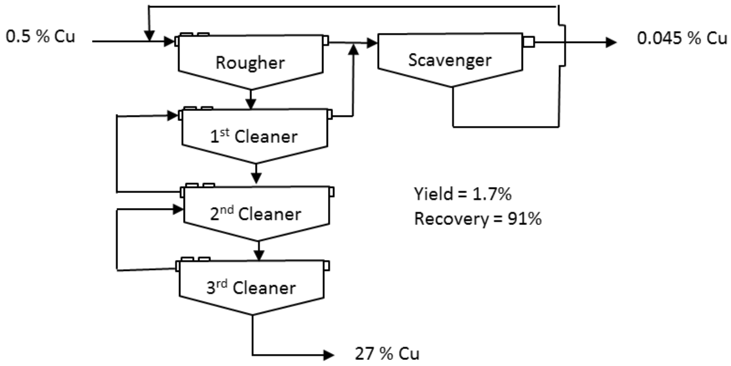

Figure 9
Example of a flotation circuit to recover copper

Another major difference between base metal and coal processing is the so-called mass pull, or yield. In base metals circuits, the yield is low and the multiple processing stages and circulating loads are necessary to achieve high recoveries. Most tailings streams cannot be operated in open circuit. In contrast, coal applications have very high mass reporting to the concentrate. For example to achieve the same recovery (91%) as the base metal example shown in Figure 9, the yield in coal flotation is 73% versus only 1.7% for copper.

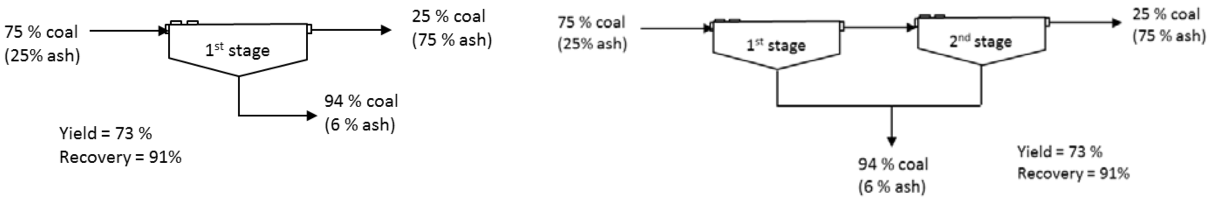

Figure 10
Typical design of coal circuits consisting of one or two-stage configurations

Therefore, it is highly advantageous to use flotation machines which have very high carrying capacity to minimise number of machines required for the duty. Coal circuits should avoid circulating loads as this will only serve to increase the carrying rates of the machine even more. Residence time is of lesser importance, particularly when treating high quality coking coal, as it’s normally naturally hydrophobic and does not rely on this factor to achieve maximum recovery. Another difference between coal and base metals flotation is the much larger volumes that are treated which is mainly due to the difference in feed solid content. Feed treated in coal flotation is typically 5 to 10 wt% solids compared to 20-40 wt% solids for base metals applications.

In the Australian Coal Industry, there is ongoing debate about the merits of Jameson Cells arranged in single versus two-stage configurations. Figure 11 compares the performance of two operating plants treating the same feed in these two configurations. The Jameson Cell produces a low ash concentrate at very high (70 to 90%) combustibles in both cases. This highlights the robustness of the Jameson Cell in either configuration.

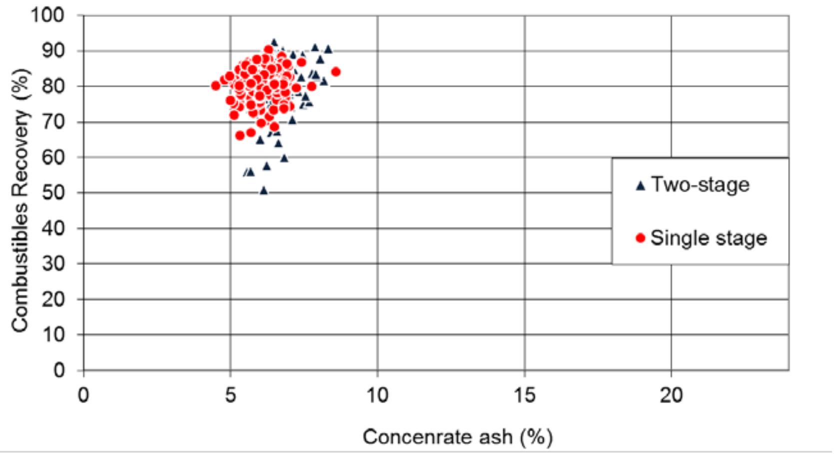

Figure 11
Comparison of Jameson Cell performance in single and two-stage configuration; using data from two operating plants

Bearing all this in mind, the design of any flotation circuit should never rely on a “one-size-fits-all” approach, as a critical driver for the design is the coal(s) treated. Every source of coal is different and is also likely to change over time as a result of changes in the deposit and in the mining conditions, etc. Factors relating to surface chemistry on the flotation process become more important as coal quality decreases. Therefore, circuits designed for poorer quality coking coals, oxidised or weathered coal and thermal coals of varying rank, need to carefully consider other aspects such as reagent addition control (i.e., some may need staged addition), if reagent emulsification is required and conditioning for proper adsorption of collector on coal particle surfaces. For example, it is the variable nature of these various types of coal that lends itself to adopting two-stage circuit designs.

It is also important to highlight that two-stage Jameson Cell circuits do not need double the amount of cells compared to a single-stage circuit if treating the same amount of feed. Single stage circuits are designed at higher tailings recycle, typically around 40 to 50% because the higher recycle is required to ensure the cells can have sufficient carrying capacity to produce the desired product tonnage. In two-stage circuits, the recycle is reduced to 10 to 20% and designed only to dampen fresh feed fluctuations and thereby ensure that the Jameson Cells can be operated at a constant feed pressure and volumetric flow rate. In most cases, the total number of cells will be the same, although the two-stage stage option will probably require the next cell size larger than the cells chosen for single-stage.

CONCLUDING REMARKS

The Australian Coal industry was a leader in adopting advanced flotation technologies such as the Jameson Cell, into its operations in the early 1990s. However, in many subsequent installations, inadequate design and improper integration of the fines circuit into the overall washing plant have prevented operators from realising the full benefits of this improved technology. Myths perpetuated in the industry relating to flotation, from fundamentals aspects to the machines themselves, have not helped operating plants to identify and address the real issues. It is hoped that the explanations and discussions in this paper will help to address these myths allowing sites and the Australian Coal Industry in general to focus their efforts towards overcoming the current challenges. Proper education and training is necessary for operators to better understand and appreciate the complexity of the flotation process, and to learn that the surface chemistry aspects are just as important as the machine used. In our view it should be mandatory for all plants to measure the flotation performance in order to be able to manage it. Performance must be quantified to allow each site to gauge the current performance and then implement solutions to debottleneck the fines circuit as necessary. Only then will the Jameson Cell circuits be used to their full potential. It is hoped that the proven performance of the flotation circuit demonstrated from three sites reported in this paper will help other sites realise that such improvements are possible and therefore motivate them to do the same. There are many lessons to be learnt from overcoming the current challenges and these must be institutionalised by every operating company to ensure that mistakes are not repeated in new their plant designs and projects.

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