Australian coal preparation—a 2000 review

by A. Swanson*

Synopsis

The Australian coal industry has been subdued in recent years and only a few new plants have been constructed, but the drive for greater efficiency has seen continued technological developments. The paper lists the new plants and major upgrades, plus summarizes technical developments in the areas of dense medium processing, fine coal treatment, froth flotation, dewatering and on-line analysers.

Introduction

This paper is a reflection on the developments in coal preparation in Australia for the period since late 1997, when an excellent summary was prepared for the last IOC seminar on coal preparation developments in each country (Hornsby and Partridge[1998]). Fortuitously, the Eighth Australian Coal Preparation Conference was held in November 2000 and much of the technology developments discussed below come from the papers presented at the conference.

Note, that the views expressed are personal and do not necessarily represent the views of the Australian Coal Preparation Society.

General coal industry view

The last three years for the Australian coal industry have been very difficult, perhaps the toughest since the early 1980s. Low prices have prevailed for much of the time but exports have continued to grow for the three-year period and the relevant statistics are given in Table I. While contract prices were low, spot thermal coal prices were very low for periods of time, but these have dramatically improved over 2000; the lower A$/US$ exchange rate enhanced profitability for coal mining operations in the latter part of 2000. The focus has very much been on reducing costs which has inevitably led to restructuring and lower employment levels in the industry. Recently focus has switched back to improving the efficiency of operations, prompted by an improved outlook for the industry.

One of the notable features for 2000 in the Australian coal industry, has been the changes to, and consolidation of, the ownership of Australian coal mining operations (Table II). However, the significant passive minority ownership by Japanese trading companies has not changed. There have also been a number of smaller operations open up, with many making use on contracted services for mining, preparation and haulage. Such ventures include Coppabella, Foxleigh, Whitehaven, Cullen Valley, Glennies Creek, Nardell and Donaldson.

The Australian industry relies heavily on exports, as shown in Table I, so the future of the Australian coal industry depends substantially of overseas sales. Current projections from government and industry sources indicate only very minor increases in coking coal exports but substantial increases in thermal coal exports, to 147 Mt/y in 2010 (Haraldson[2000]). Such an increase will require substantial projects to come on line, which will not only require the increased demand, but also the likelihood of a reasonable return on the capital invested.

Plant construction activity

The difficult period for the industry resulted in only limited construction activity for new and upgraded preparation plant facilities. Some of the more significant projects brought on line in the period 1998–2000 were:

Burton Coal—second module commissioned; 400 t/h of feed in each module with two-stage processing of coarse coal in 1300 mm diameter dense medium cyclones, sands fraction in spirals and Jameson cell flotation on

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Table I

Production statistics for Australian coal industry

(2000 data are provisional; source Aust. Coal Report)

	1999 Production (Mt)			2000 Production (Mt)		
	Qld	NSW	Total	Qld	NSW	Total
Saleable output	122.9	106.1	229.0	129.5	105.8	235.3
Metallurgical exports	68.7	23.3	92.0	76.4	24.1	100.5
Thermal exports	30.6	48.8	79.4	34.7	51.7	86.4
Total exports	99.3	72.1	171.4	111.1	75.8	186.9
Exports to Japan			79.8			87.8
Exports to Asia zone			119.4			127.8

Table II

Significant operators in the Australian coal industry

(covering approximately 90% of saleable production; source Aust. Coal Report)

Company	December 1999 Capacity (Mt/y)		December 2000 Capacity (Mt/y)		
	Managed	Owned	Managed	Owned	Mines
Anglo Coal	0	0	25.8	22.8	8
BHP	51.3	33.7	51.1	37.8	17
Billiton	7.3	5.7	7.5	5.9	3
Cyprus	12.1	6.7	0	0	0
Exxon	9.0	5.4	5.6	2.0	1*
Glencore	14.1	10.8	27.9	19.6	11
Idemitsu	7.3	6.8	8.5	7.8	3
MIM	19.1	14.3	19.6	14.7	6
Peabody	15.9	9.8	0	0	0
Powercoal**	10.6	10.6	12.1	12.1	8
QCT	5.2	11.4	0	0	0
RAG	4.0	3.8	6.4	5.2	2
Rio Tinto	37.9	28.7	55.9	38.7	12
Shell	26.5	18.2	0	0	0
Sumitomo Corp	3.0	4.3	0	1.2	0
Wesfarmers	2.9	4.3	7.0	8.4	3

* Sale pending

** Sale of assets under consideration

the ultrafine fraction. Later the first module was modified in light of technological advantages from second module, which included the 1 m diameter classifying cyclones and the Climax magnetic separators.

Moranbah North Coal—complete new plant was constructed to treat 1500 t/h in two modules; in each module coal is processed in a Teska Bath, two 1 m diameter cyclones and three Jameson flotation cells.

Coppabella—a new plant was installed to treat 600 t/h of raw coal in a large diameter dense medium cyclone (+1.4 mm w/w) and spirals (deslimed –1.4 mm w/w).

Saraji—replacement of conventional flotation cells by Microcel columns. Eight 4 m diameter cells were installed to treat 400 t/h of –0.5 mm coal.

Warkworth—addition of a module to treat the ultrafine fraction in Jameson cells and screenbowl centrifuges to provide a Beneficiated Dried Tailings (BDT) product to the specifically designed Redbank Power Station (Mills, *et al.*[2000]). Classifying cyclone overflow, normally sent directly to the thickener, is processed to provide 58 t/h (dry) of product coal with an ash of less than 15% and total moisture of 26–30%. The plant was commissioned in late 2000 and is undergoing operational trials.

South Walker Creek—preparation plant capacity was increased by installing a larger diameter dense medium cyclone (1300 mm) and additional spirals.

Blair Athol Coal—a 250 t/h contractor supplied and operated plant upgrades coal that contains too much dilution and so has been excluded from the raw coal export steam product. The plant consists of dense medium and spiral circuits.

Callide—two ROMJIGS, capable of handling around 350 t/h each of very coarse coal, have been installed to treat –350+75 mm coal (-75+40 mm can be optionally included); commissioning is expected March 2001. Raw coal from the mine (2000 t/h) is broken to 350 mm topsize and screened, with the coarse coal washed and the undersize coal passing straight to product. The product coal, consisting of washed and crushed coarse coal, and raw undersize coal, is supplied to regional power stations. Overseas studies indicated that cutpoints of 1.77 to 2.0, at Eps of 0.07 to 0.10, could be achieved (Sanders, *et al.*[2000]).

Technology developments

Washability data

With lower levels of operating profits, it is becoming increasingly important that mine planning procedures are reliable and accurate, and that all options to optimize returns are considered. The projection of likely yields from coal preparation is a crucial step in such a process. Also, the designers and operators need to provide coal preparation plants that have minimum capital cost and maximum efficiency. Thus reliable sizing and washability data are essential.

Industry and government have funded extensive investigations into better sample pretreatment (Swanson[2000]). These were derived from an understanding of the breakage that occurs in coal handling and preparation facitities, as shown conceptually in Figure 1. The procedures developed are now finding common usage in the testing of large diameter bore cores and strip samples. The procedure involves drop shattering to the point of 'inevitable breakage', further drop shatter to model the breakage in handling systems, dry tumbling to incorporate abrasion and five minutes of wet tumbling to achieve the in-plant wet sizing. When detailed float-sink work is carried out on a number of size fractions, and these data used in a simulation model, close matches to plant performance can be achieved (Esterle, *et al.*[2000], Figure 2).

However, large diameter cores are relatively expensive to obtain and test, so the number and spread of results are usually quite limited. To obtain sufficient volumes of data for geological modelling and mine planning, it is common to use large numbers of slim cores. Such cores have only a small mass and so the detailed data required for reliable projection of preparation plants have not been traditionally obtained. As part of a larger project on fragmentation, adjacent slim and LD cores were drilled and the washability results were used in simulations to compare to plant results (Esterle, *et al.*[2000]). It was found that by pretreatment of the slim core, and by

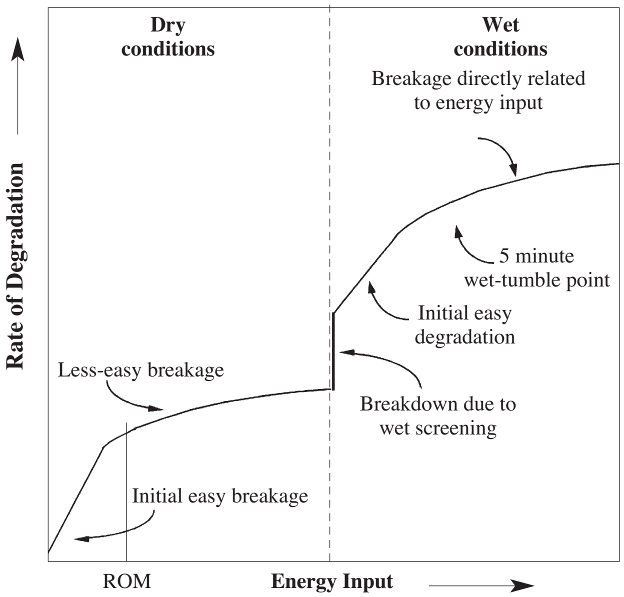

Figure 1—Conceptual breakage model for coal handling and preparation

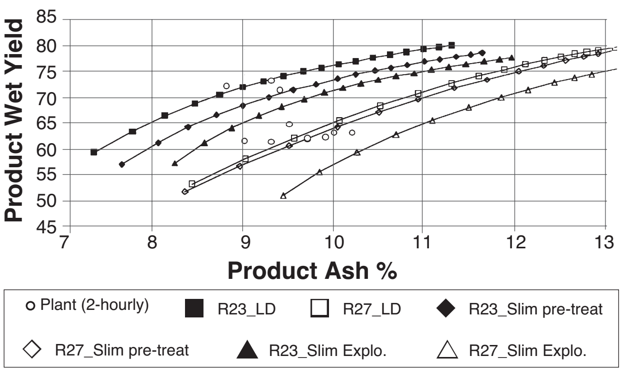

Figure 2—Comparison between plant performance and simulations of bore core data

doing more detailed float-sink work, better yield estimates were obtained than from standard exploration techniques, as shown in Figure 2. Results were not as good as for large diameter cores but because of the potential wider geographic distribution, the use of pretreated and fully tested slim cores warrants further consideration.

Dense medium processing

The trend continues to the use of modules with single large diameter dense medium cyclones, with units up to 1300 mm in diameter that can process 450 t/h of coal and more. In plant refurbishments, single large diameter DMCs are replacing pairs of smaller diameter units. There are some emerging concerns about the efficiency of separation for the smaller coal (say -4+1 mm) and this will be the subject of an ACARP- funded study in 2001.

The Climax style magnetic separators, which feature a counter rotation technique, offer higher unit capacities, better efficiencies and higher concentrate densities. These styles of units have allowed simpler and more effective dense medium circuits to be designed. As a result, most new installations employ such units.

Banana screens have been widely used in desliming and drain and rinse applications because of their increased screening capacity per unit of footprint area, compared to conventional sieve bend/low head screen combinations. However, the ‘drain’ performance is critical to the operation of dense medium circuits and an ACARP study has investigated this aspect of banana screen operation (Meyers, *et al.*2000). The findings from this project were that the drain behaviour of banana screens were, for the same apertures, inferior to sieve bend/low head screen combinations (Figures 3 and 4). However, the rinse performance of banana screens was superior and overall the total screen performance shows better moistures and lower magnetite losses. The poor drain performance of banana screens is marked below effective cut sizes of 1 mm and the different balances of drain and rinse flows need to be taken into account at the design stage.

The replacement of sieve bend/low head screens with banana screens has focused attention back on the operation of density control systems (Leach and Meyers2000). A variable drain rate, particularly a low one induced by the retrofit of a banana screen, more strongly impacts on the traditional DSM system (using an overdense sump to correct medium density in feed), than the now more common rising

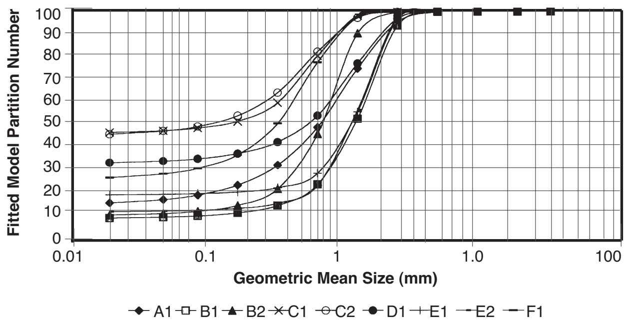

Figure 3—All modified Whiten model fitted drain section data (B2 sieve bend/low head with 0.55 mm aperture; C1, C2, F1 banana screens with aperture 0.56 to 0.8 mm; the rest banana screens with apertures 1.1 to 1.7 mm)

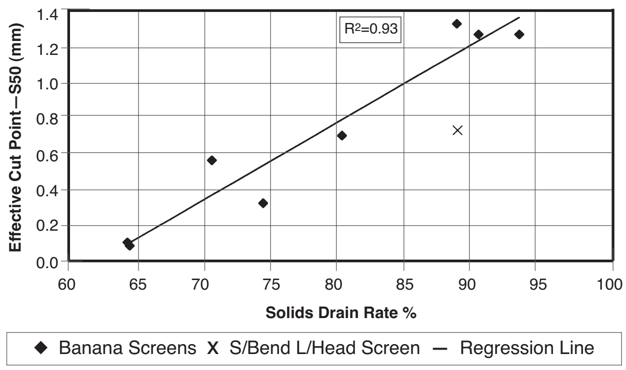

Figure 4—Solids drain rate% v effective cut point (S50) with sieve bend/low head data point shown

density system (concentrated medium from dilute circuit returned immediately and make up water used to correct density). Thus the replacement of sieve bend/low head screens by a banana screen, in a plant employing a traditional DSM density control circuit, can have catastrophic effects if the density control system is not upgraded.

The Macquarie coal preparation plant has benefited greatly from a project to improve the magnetite control circuit (van Barneveld, *et al.*2000). The original design had separate dilute medium treatment for the DM bath, primary DMC and secondary DMC circuits. The new design had a single dilute circuit with just two Climax magnetic separators and there is a controlled redistribution of magnetite back to each circuit. The simplified circuit contains 17 pieces of equipment compared to the original 58. Magnetite consumption has fallen from 1.3 kg/t to 0.4 kg/t, plant availability has increased to 87%, control has become simpler and operations have greatly improved.

While the operation of dense medium cyclones is well understood in overall terms, a better understanding of medium behaviour, and the prediction of underflow and overflow densities, will enhance modelling and process control. As a result a project has commenced at JKMRC that uses gamma ray tomography to determine the internal medium gradients (Lyman, *et al.*2000). A rig has been developed using a 350 mm diameter DSM style dense medium cyclones, and techniques to extract useful data have been established, so results should become available over the next year or so.

A novel cyclone concept has been developed by the JKMRC (Rong and Napier-Munn,2000) that, by using special profiles for the body, vortex finder and spigot, increases centrifugal forces and mitigates short-circuiting (see Figure 5). The objective is to improve the efficiency of dense medium processing of smaller particles, say –4 mm. Pilot testing of the dense medium separation of a 100 mm diameter new cyclone and a DSM type cyclone showed some improved performance using tracers and coal (-1+0.125 mm) —sharper separation, lower cutpoint offset, good efficiency at low cutpoints. Work is progressing to a 200 mm diameter design.

Fine coal processing

A one metre diameter classifying cyclone, cutting between 0.2 mm and 0.3 mm, offers a number of distinct advantages over traditional multiple cyclones carrying out the same duty—reduction in capital and maintenance costs, simpler layout, elimination of slurry subdivision step. Performance data are difficult to establish due to the volume of samples that are required and so ACARP funding was made available to obtain such information (O'Brien, *et al.*2000). It was found that similar efficiencies to banks of smaller cyclones were obtained and that similar relationships are found with respect to the impact of variables such as flowrate, pressure, and geometry on separation size. Increasing feed solids from 10% to 20% increased the cut size from 0.2 mm to 0.3 mm. The behaviour of particles of different densities was marked with the high density particles separating at 0.07 mm and the cleanest coal separating at 0.3–0.5 mm.

The novel cyclone design described above in dense medium processing, also can be used for fine coal classification (Rong and Napier-Munn2000). Pilot testing was carried out comparing the performance with two commercially available 100 mm diameter classifying cyclones. Generally the JKMRC cyclone gave a sharper separation and, for a given feed pressure, the JKMRC cyclone gave a lower separation size, demonstrating the higher centrifugal force present. Also, under similar test conditions, the novel design gave a lower flow ratio to underflow. The next steps are evaluations at 200 mm diameter and then plant trials.

After a series of pilot trials and simulation studies, Bayswater Colliery Company decided to upgrade their coal preparation plant by employing a Teetered Bed Separator (TBS) to process the –2+0.5 mm size fraction. The treatment of this fraction took load off the water washing cyclones and spirals and was a cost effective upgrade. Overall plant capacity increased by around 100 t/h and yield increases of 1.5–2.5% were expected. The plant flowsheet is given in Figure 6, with installation occurring in April 2000, commissioning in May 2000 and successful operation since.

Froth flotation

Apart from the two major installations of Microcels at Peak Downs and Saraji, new plants and upgraded plants have included Jameson cells, e.g. Burton Downs, Moranbah North, Blackwater. As the technology has become more accepted, further development has been undertaken (Murphy, *et al*, 2000). Carrying capacities are historically difficult to predict for column flotation, and Jameson cells in particular; investigations have derived more accurate methodology to reduce the conservatism in design. High Intensity Conditioning (HIC) has shown that with no additional reagents micro-agglomerates can be generated which improve the flotation response of difficult to float ultra-fine coal. A third generation Jameson cell is now available that incorporates a SpinFlow wash water system, to improve wash water distribution, and an air isolating slurry eliminating valve, to minimise ingress of solids into the air distribution system.

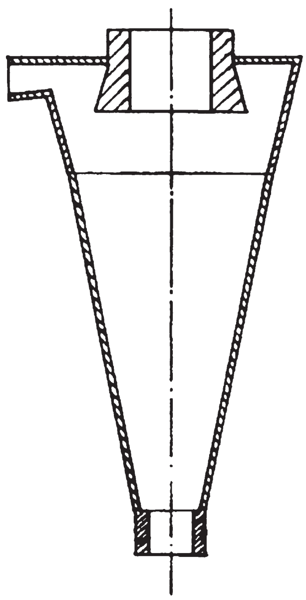

Figure 5—Schematic drawing of the new cyclone design concept from JKMRC

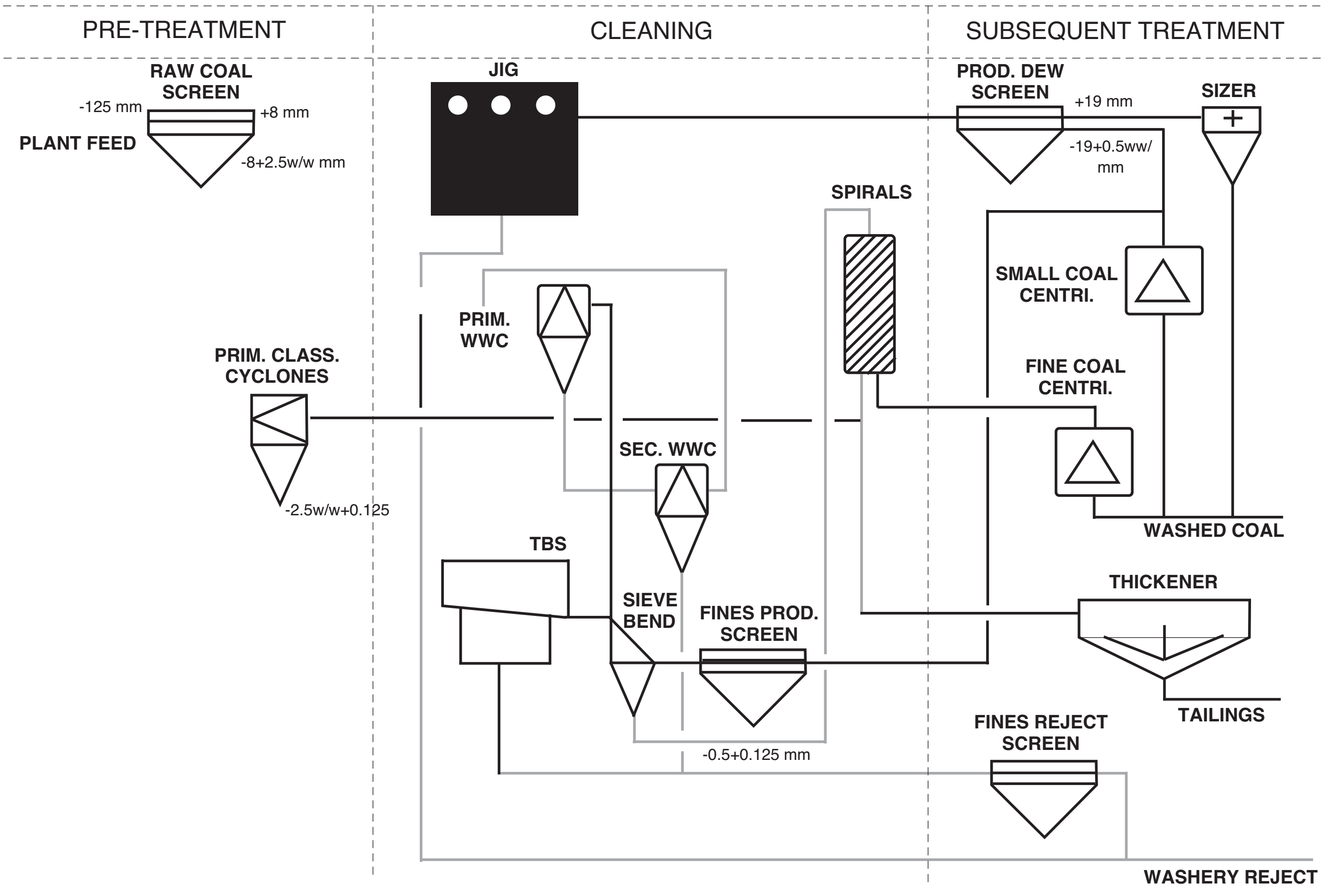

Figure 6—Bayswater TBS™ plant upgrade as-built process flowsheet

The CSIRO-developed TurboFlotation process has continued its development with the trial of a 1 m diameter unit at the Coppabella mine, treating the –0.1 mm fraction in one or two stages (Ofori, *et al.*2000). The process aims to provide low cost, compact high capacity flotation cells by improving residence times by an order of magnitude by isolating the sub-processes of bubble generation, particle/bubble contacting, froth/slurry separation and froth crowding/removal (Figure 7). Successful trialing at bench (90 mm diameter) and pilot (300 mm diameter) provided confidence to scale up by a factor of 40 times to 1 m diameter. The demonstration plant has been operating since June 2000, and while a number of application-specific issues have been identified, there have been some scale-up issues that need to be attended to before the unit can achieve optimum performance.

Studies have indicated that cavitation forces can improve flotation yields and reagent consumption (Attalla, *et al.*2000). The mechanism is believed to be associated with the formation of picobubbles on the surface of coal particles (Figure 8). Cavitation was induced by the use of ultrasonic waves but it is possible that the same effect could be obtained using properly designed orifice plate type generators.

A froth vision system has been developed by the JKMRC that captures, digitizes and analyses images from flotation froths on-line to assist control room operators and to provide data for automatic process control (Nguyen, *et al.*2000, Figure 9). The information provided includes bubble size, froth texture and froth velocity, and control strategies have been developed using such data. Prototypes were trialed at Peak Downs and full commercial systems are being installed at both Peak Downs and Saraji Mines.

Dewatering

When looking to dewater fine flotation products, the choice has been usually a horizontal belt vacuum filter, such has been the case at Burton Downs and Moranbah North. For

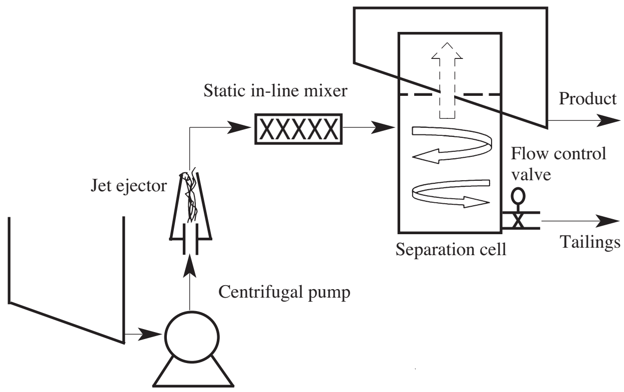

Figure 7—The TurboFlotation system

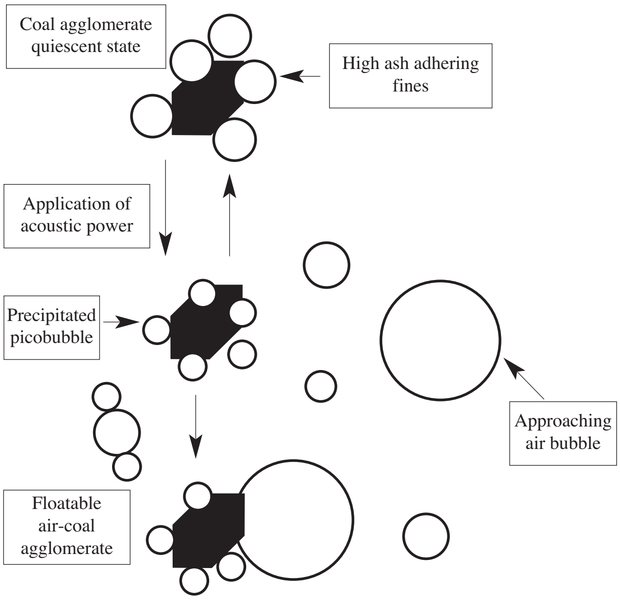

Figure 8—A proposed mechanism for picobubble assisted flotation

deslimed fine coal products, fine coal vibrating basket centrifuges are generally selected.

For all types of fine coal dewatering, the optimum use of, and mixing with, flocculants is an issue. There are a set of conditions for both in-line mixers and stirred tanks that give optimum filter performance in terms of moisture reduction and cake rate (Rong, Thonangi and Fulton[2000]).

The application of air purging to basket centrifuge operation has been demonstrated in principle and in practice, with moisture reductions of up to 1% possible (Condie, *et al.*[2000]). This concept has been extended into an air-purged chute in which the feed is confined in a closed chute, equipped with an air knife and a discharge screen (Figure 10). Preliminary results indicate that moistures equivalent to those obtained in plant centrifuges can be obtained.

On-line analysers

On-line analysis has been developed extensively in Australia over the years. Edward and Clarkson[2000] have found that there was a perception that gauges had not lived up to initial expectations, but still delivered value. Users need to be aware of the limitations of the technologies, the need for proper sampling and analysis to maintain calibrations, the impact of variations in mineral matter and the proper application of on-line technology. Providers of on-line analysers need to provide equipment that is reliable and stable, and to properly advise prospective purchasers of the technology of its limitations and the need for significant calibration efforts. Guidelines for gauge selection and calibration have been developed and case studies have demonstrated how on-line analysers can be profitably deployed.

Scantech have been trialing an on-belt version of their PGNAA 9500 technology, with beta testing in progress since early 2000. Preliminary results indicate that precision levels at least equivalent to chute-based analysers are being obtained. The obvious advantages of such a unit, are that the need for, and the problems associated with, a sampling plant are avoided.

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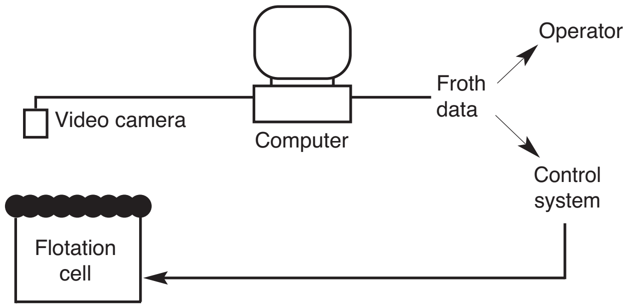

Figure 9—Schematic of the froth image analysis system

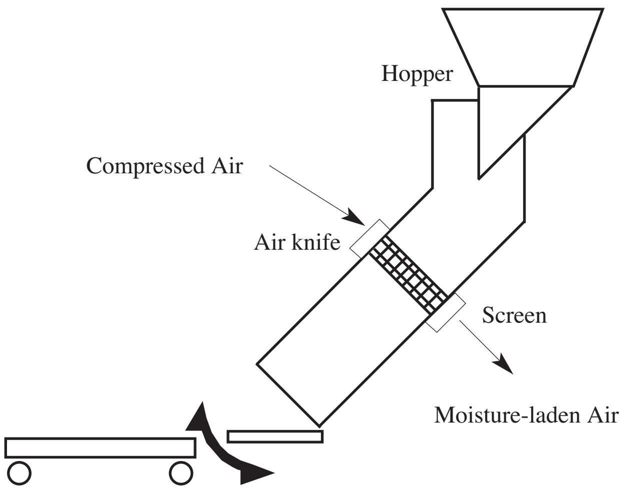

Figure 10—Schematic of the pilot scale jet chute

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Lightnin USA acquires and merges Aeromix (Pty) Ltd and Aeromix Process Systems*

Lightnin USA has acquired Aeromix (Pty) Limited and Aeromix Process Systems for an undisclosed figure and merged the companies to form Lightnin Africa.

The corporate giant is a division of SBX—a listed New York stock exchange company with an annual turnover in excess of $3-billion. Lightnin Africa will be responsible for the manufacture and marketing of its products in sub Saharan Africa.

'The acquisition, which has taken a year to conclude, will have major benefits for our many clients,' says managing director, Warren Dale. 'Lightnin Africa, as a wholly owned subsidiary, now has direct access to Lightnin plants and facilities throughout the world, ensuring the most competitive source of supply for our mixing equipment.'

'Factories in the UK, USA, China and Singapore, as well as our plant in South Africa, will produce high quality Lightnin mixers to a uniform standard,' said Dale.

Lightnin is the largest supplier of mixers and agitators for general industrial use in the world and are renowned for supplying top quality products developed through extensive research and development programmes.

The US investment will give the SA operation a platform to improve its export market using the extensive international Lightnin network. The equipment will be manufactured locally.

Lightnin Africa now has access to international testing and design facilities that will further improve the South African technology available, designed for the most arduous mining conditions.

Says Mark Craddock, manager process equipment. 'Our pricing structure has now changed as a result of the buy-out and will mean we can now provide customers good quality products and service at improved prices.

In addition to our existing range of products, plans are under way to not only improve these, but we are now in a position to look at other opportunities now available to us,' he said.

Lightnin has been involved in development of process equipment for many years. With the acquisition of Aeromix Process Systems it introduces a new dimension to the company's portfolio internationally. Aeromix Process Systems has designed and patented equipment for South Africa—this equipment will now be available to the international market.

The process range includes attrition scrubbers that have gained market acceptance in southern Africa, thickeners with a distinctive design feature from others available on the market and the locally designed and developed 'Flotrition'. The patented 'Flotrition' is the only unit of this type in the mining industry which is a combination of flotation and attrition scrubbing in one single unit.

Lightnin are experts in gas dispersion and gas hold-up, slurry agitation, solvent extraction and other complex chemical, metallurgical and process systems. Another area of expertise is large gearbox manufacture.. ◆

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GREEN TOPICS

Tax-leveraged plan for rehabilitation of mining property

In terms of the Minerals Act, a mining company is obliged, upon closure, to rehabilitate the land concerned, to the satisfaction of the Regional Director of the Department of Minerals and Energy (DME). To achieve the funding of this activity efficiently, a newly established and practical option for funding of future rehabilitation/closure costs in the mining industry has been developed. In this new funding option, investments/savings can be made towards future rehabilitation costs of land or the environment, with the mining company receiving tax concessions as 'expenditure' under Section 11(hA) of the Income Tax Act, provided that such savings are effected through the correct vehicle (which is a registered environmental trust). Additional tax exemptions are available under Section 10(1) (cH) in respect of such savings.

Most of the larger mining companies have established their own in-house rehabilitation trusts in order to obtain the tax concessions provided.

As a result of recent negotiations with the South African Revenue Services (SARS) and the DME, this facility can now be offered to those mining companies which do not wish to spend the time or money in administering their own trust. By outsourcing this function they can enjoy the tax concessions and tax-exempt status of their savings plans, professional management of their closure funds, and can then concentrate on their 'core' business of mining. Further, for those companies in joint ventures with 'other' mines, this outsourcing avoids the 'contamination' of the J.V. partners' own in-house trusts, since the administration and investment is managed by an independent and well respected asset management team.

The facility which has been developed is fully compliant with the requirements of the Commissioner, Mining Taxation at SARS. An 'umbrella' Section 21 Company has been established to utilize the tax benefits available under Section 10(1)(cH) in respect of investments towards future mining rehabilitation, made by a mining company and thus claimed as expenditure under Section 11(hA) of the Income Tax Act.

Terms of investment have been approved which specifically authorize this umbrella 'trust' to invest monies in Assets, Securities and Insurance Policies with registered Insurers as contemplated in the Long Term Insurance Act (No. 52 of 1998).

Old Mutual has designed an investment product offering a wide yet logical selection of retail investments, ranging from guaranteed investments to 'optimized funds' which are risk differentiated (to accommodate the client's risk profile) to Rand denominated asset swop unit trust funds, to provide opportunity for growth and Rand hedging facilities.

Key features of the investment strategy are:

- ➤ Capital Security
- ➤ Guaranteed Minimum Returns
- ➤ Long Term Capital Growth
- ➤ Rand Hedging
- ➤ Liquidity.

Further information can be obtained from Errol Hicks at
Telephone Number (031) 2504000/2504019,
Cell Number 0832343160,
Fax Number (031) 2083210. ◆

Pump selection software program available*

Keeping in-line with international specifications, Svedala SA has launched a new pump selection software program.

The CD-Rom program has been designed to assist mining engineers with finding the correct pump for specific applications.

'It is definitely a worthwhile program', says Gary Moore, manager Svedala's pump division, 'it saves time allowing engineers to specify their own units according to the media being pumped, and best of all, it's free.'

'As new ranges are designed and developments occur, programs are upgraded. The package uses minimal space on computer-aided design systems', says Moore.

Technical information and the full range of Svedala's pumps are also available on CD-Rom.

For further information contact Gary Moore
Tel: (011) 397 5090 – Svedala South Africa. ◆

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