Upgrading of coal in preparation plants is becoming much more important as the environmental pressure against coal mounts while global demand for energy counters that with growing need for coal, preferably clean. Wood Mackenzie recently presented a paper to clients titled *Upgrading Indonesian coal margins*. It says that while coal upgrading technology has yet to be proven, the race is on as there is great commercial potential. Indonesia especially is in a good position to benefit as low rank coal projects will achieve higher operating margins and increased market opportunities through an upgraded product. This means Indonesia will be competitive with bituminous coal producing countries as well as increase commercial attractiveness for investors.

In the Indonesian example, the imperatives are more economic than environmental. South East Asian Coal Supply Lead Analyst, Rudi Vann says, "Indonesia is in a position to benefit because it has large quantities of low rank coal which has a limited consumer base and cannot enter the traditional thermal markets of North Asia in large volumes. Heavy discounting on coal prices are required to capture the market share, eroding returns for investors. Upgraded coal will bring substantially higher operating margins, as this price discounting will be eliminated, despite having higher capital and operating costs."

Using Wood Mackenzie’s Global Economic Model (GEM), the Tekno Orbit Persada project was used as an example to analyse the implications of implementing upgrading technology. It is located in the Wahau coal field, which contains several billion tonnes of low rank resources. Total capital costs will double and operating expenditure over the life of the mine will increase by 24%. This is offset because the total increase in gross revenue is significantly more than the increase in operating costs thanks to the removal of heavy price discounting.

Vann says, "There will be an overall higher net cash flow over the life of the project. Increased margins will result in a Net Present Value three and a half times that of the base case from $816 million to $2.9 billion for the upgraded product. Even though more capital is required, the payback period for investors actually decreases due to the increased value of the coal. Breakeven price also improves allowing for greater resilience to price shocks and better absorption of volatility in capital or operating expenditures."

Indonesia’s upside scenario still faces several challenges to becoming a reality. Firstly, the technology for upgrading low rank coal to a bituminous product has yet to be proven in large commercial quantities. Secondly, implementation of the technology and access to upgrading facilities in the industry has yet to be determined. Lastly, there lies an uncertainty as to acceptance of the product and a complete transition to the upgraded coal product is unlikely.

Vann summarises, "Coal upgrading technology has come a long way and can have considerable impact on returns of low rank coal projects in Indonesia. If proven, we expect a significant change in export thermal supply and trade flows. Investor reaction will also likely change to now consider Indonesian projects using this technology as economically attractive options."

**Breaking and screening**

Awarded to Bateman Engineered Technologies (BET), part of the Bateman Engineering Group, the fast track lump-sum turnkey contract for the provision of coal handling infrastructure for Klipspruit Colliery in Mpumalanga, South Africa, covered the supply of a run-of-mine (ROM) ore tip, secondary screening/crushing facilities and interlinking conveyors. The R146 million contract for BHP Billiton Energy Coal South Africa (BECSA) was conducted in two phases. In Phase One the ROM tip was commissioned (live capacity 500 t), as where a 1,750 t/h rotary breaker, and four of the six conveyors (the ROM feed, reject, tertiary crusher feed and splitter feed conveyors). In addition, equipment free issued by the client was installed and commissioned, including a chain feeder, and the primary and tertiary mineral sizers.

The two bypass feed conveyors and Buffalo reclaim feeder comprised Phase 2. The total length of the new conveyor system is 1,070 m, with the largest belt width being 2.1 m. The system is designed with conveying speeds varying from 0.7 to 3.5 m/s and tonnages to be conveyed of up to 2,500 t/h. A design feature of this conveyor system is the need, due to space constraints, for the tertiary
crusher feed and splitter feed conveyors to be “piggybacked”, requiring a specially designed support structure.

Another design challenge was the high elevation of the screen and the need to ensure that such a large vibrating piece of equipment was stable at this height. In addition, the reject bin, with a capacity of 500 t, was conveyed piecemeal to the site due to its size, where it was welded together. A special steel grizzly located in the ROM tip concrete bin provides enhanced wear performance under the abrasive conditions of the product handled at Klipspruit. The grizzly was manufactured in three pieces, each weighing about 26 t. In line with BHP Billiton’s environmental standards, dust suppression equipment was installed at all transfer points as well as at the ROM tip.

The Klipspruit contract is part of BECSA’s expansion to this mine where capacity is increasing from 4.8 to 8 Mt/y. The increased coal production supplies both Eskom (the South African national power utility), as well as export customers. The coal is processed through the Phola Coal Processing Plant, a joint venture between BECSA and Anglo Coal, which processes 16 Mt/y, 8 Mt of coal for each partner.

BET reports that demand for Bradford Breakers continues with the most recent order being a breaker for Optimum Collieries in South Africa. With the commissioning of this unit, there will be more than 20 such breakers in operation in South Africa.

Optimum Collieries’ 4.2 m diameter by 8.5 m long Bradford Breaker will be used in a secondary-crushing application to process some 1.400 t/h of ROM coal to a product size of -100 mm. BET is responsible for supplying, installing and commissioning the Bradford Breaker, which was manufactured in South Africa under licence to Pennsylvania Crusher.

The many benefits of the Bradford Breaker include the ability to handle large lumps of ROM material without the risk of blockages and the ability to simultaneously size and clean raw coal. Fines generation is minimised as the coal is fractured along natural cleavages. The internal lifters can easily be arranged to accelerate or retard the material flow rate through the machine and, as the machine is designed to contain dust, effective extraction and treatment of dust-laden air are possible.

The machine is easy to maintain and repair, as it is driven from one end only by a simple drive assembly. Low operating costs and downtime are added benefits.

A new design drum introduced a few years ago enhanced the robustness and rigidity of the drum as well as facilitating maintenance of the drum in situ. The grid-type screen plates result in a longer plate life and greater drum capacity from the increased open area.

Another Bateman company adds further coal prep technologies to the Group’s offerings. Delkor India has commissioned India’s largest horizontal belt filter (HBF) for coal filtration at Tata Steel’s West Bokaro Coal Washery III. This is also the world’s largest HBF with effective filtration area of 145 m² for coal slurry. West Bokaro’s Washery II was the first to implement Delkor belt filters with effective filtration area of 64 m². Delkor says the success of the project “is the result of Tata Steel’s vision for adopting advanced technologies and Delkor’s exhaustive filtration tests and rich coal filtration experience from more than 60 installations by Delkor in Australia and other parts of the world.”

The complete belt filter was erected at site. The filter was commissioned during August 2009 and has replaced existing dewatering centrifuges. Tata Steel is benefiting from power savings and eliminating loss of solids by the change.

The particle size range of clean coal is -0.5 mm. The froth from flotation cells is thickened in one of Delkor’s high-rate thickeners to 30% solids w/w and fed to the filter. The filter is designed to handle 45 t/h of solids (dry basis) and moisture in the discharge cake is as low as 22% w/w.

Collaboration between Brisbane-based Ludowici and Australia’s University of Newcastle has resulted in the development of the Reflux Classifier (RC). Ludowici describes this as “a step into the next generation of mineral processing and is rapidly gaining global attention as a high efficiency, high capacity, upstream mineral separator used in the mineral beneficiation process.”

The RC achieves significant efficiency gains, which allows for larger yield increases and enhanced product quality compared to current technology. Its unique feature is the use of lamella plates in the up-flow slurry to enhance the settling rate. These are used in combination with the autogenous mixing/ feed zone directly below the plates and high density reject bed in the bottom of the unit. Lamella plates are a rack of inclined extruded plastic plates that sit above the feed zone. The alignment of the plates provides a streamlined and uninterrupted flow of particles. The higher settling rate above the feed zone enables higher feed rates and a wider range of feed conditions and higher efficiencies than conventional classifiers.

In addition the higher density rate enables the RC to sort particles by density instead of particle size. Lighter particles float to the top and the denser particles sink to the bottom, allowing them to migrate to a central discharge port.

The RC has the added bonus of taking up less floor space than current technology. It can be fed up to 120 t/h in coal applications where other classifiers would require six times the floor space to achieve a similar capacity.

Ludowici and the University of Newcastle have collaborated on this product since 2007 and together have won a B-Hart award for best collaboration between industry and university.

The Cavex hydrocyclone was developed in
the later part of the 1990s as a result of expertise developed by Weir engineers in slurry pumping. The Cavex design, featuring a unique laminar spiral inlet geometry, was designed to deliver maximum efficiency, maximum capacity, and longer wear life than conventional involute or tangential fed cyclone designs in mining applications. Not just a cone modification, Cavex hydrocyclones use an entirely new feed geometry that allows the slurry to follow a natural flow path within the cyclone. This results in reduced turbulence, which in turn substantially increases hydraulic capacity while minimising localised wear on the feed chamber and vortex finder. The unique Cavex shape has no sharp edges or square corners. Weir Minerals says these design improvements result in lower operating costs and fewer cyclones required for a given duty. The inlet area of the cyclone is designed to minimise turbulence and reduce wear at the feed entry point which provides more energy for particle separation at a given feed pressure.

The sharp 90° edge at the intersection of the inlet shelf and cyclone cylinder on traditional hydrocyclones causes turbulence and significant undercut immediately below the lip of the inlet shelf. To address these issues, experience with pump design was incorporated to eliminate all 90° edges in the cyclone inlet. A new cyclone inlet design was developed that includes several geometric relationships known to smooth slurry flow through the volute of a pump. The distinguishing feature of the new cyclone feed chamber is three dimensional curvature along the inlet path which forms the Cavex shape.

Since the release of the Cavex hydrocyclone line, Weir Minerals has continued to develop cyclone products to meet customer needs. Over the last several years, the Cavex offerings have been expanded, building on its success in the industry, by enhancing the optimised

Cavex shape.

Curvature along the inlet path which forms the cyclone feed chamber is three dimensional. Weir Minerals has continued to develop hydrocyclones to meet customer needs. Over the last several years, the Cavex offerings have been expanded, building on its success in the industry, by enhancing the optimised Cavex shape.

Recovering coal fines

Multotec Process Equipment's considerable success with its heavy minerals spiral plant led it to recognise the need for a similar plant in the coal industry. The plant is equipped with a de-watering cyclone, a sieve bend and a bank of four Multotec MX7 spirals with the capacity to treat 36 t/h of fine coal. The plant processes fines, saving large volumes of coal which would normally be relegated to waste dumps. The fines are first deslimed with a Multotec desliming cyclone and then passed over a sieve bend to remove the +1 mm oversize material before being fed to the spirals. The plant is inclusive of pumps and sumps to feed the spirals.

“The pilot plant offers numerous advantages,” Renira Reddy, Product Manager: Gravity Concentration at Multotec says. “It is easily dismantled, moved and re-erected. It is self-standing and engineered as a plug-and-play unit, though this depends on individual site conditions such as a ready supply of water as well as tailings disposal set-up.”

“The pilot plant is trial erected prior to its transportation to site,” adds Project Manager, Gerhard Hattingh.

“This enables the customer to give it a final inspection before moving it to site, virtually eliminating any teething problems associated with the structural layout.”

Highly competitive in terms of capital cost as well as operating costs, the Multotec coal spiral pilot plant is ideal for plants located in remote regions and can be employed as a pilot test unit, if required. Hattingh says “return on investment is rapid, with capital outlay often being recouped within months.”

If necessary, the plant can be skid-mounted which eliminates the need for extensive earthworks and civil works. It can handle a feed capacity of 40 t/h with a nominal spiral capacity of 36 t/h. “If required, larger capacity pilot plants can be supplied with little modification to the original design,” Reddy points out.

The heart of the plant is the already well known Multotec MX7 coal spiral. The benefit of the two-stage spiral design is that two separation stages are achieved in a single unit using a seven-turn spiral that uses a repulper and rejects a primary discard at turn 4. “This feature provides a lower capital investment while still maximising yield and meeting quality targets.”

The spiral is manufactured by reverse lamination and has an integral rubber edge which improves circumferential integrity and prevents spillage.

Detecting blocked chutes where coal fines are building up on the chute walls in coal preparation plants has traditionally been problematic. When the Coal is dry and flowing traditional technologies have worked well to
provide high level, low level, or blocked chute indication. Some common applications include (a) wet screens, (b) blocked chutes in the Fines Process Loop, (c) ROM Bins where water sprays are present, or... anywhere wet coal fines could build up and cause problems. Technologies include passive devices such as microwave, tilt switches, radar, etc.

When wet fines build up on an instrument it usually causes a loss of signal and the device has to be cleaned. Therefore, an active (self-cleaning) measurement is preferred. Acoustic wave technology uses a low frequency pulse that is not affected by water or dust fines. Each time the sensor pulses, a pressure wave displaces water and buildup off the face of the diaphragm. Acoustic Wave is designed for wet environments and buildup applications. Short range blocked chute applications (2 to 3 m) are the applications that give headaches.

In a recent example, an Australian mine had used mechanical tilt switches to detect blocked chute problems in conveyor transfer, chutes, screens, etc. Wet fines had built-up on the tilt switch and made it inoperable. The switch was not fail-safe and so when a blocked chute did occur the tilt switch did not operate, causing lost time to production.

Because the fines were wet at different times the mine used an acoustic switch which has the added feature of self cleaning to remove wet, sticky fines that build-up on the face of the transducers. The acoustic switch is fully fail-safe and designed to work in chutes where high water levels and ore fines are predominantly found. Each transducer uses the pressure wave affect to remove moisture and build-up. The transducers can be installed up to 700 m away from the remote amplifier.

Acoustic wave technology uses a sender and receiver form for blocked chute detection or point level detection. The transducers use software where both units pulse and receive each other’s acoustic echoes. When the path between the transducers is blocked the units immediately detect the presence/absence change of the return signal and trigger a communications relay for indication or control purposes. The transducers work both together and independently to detect pulse interference giving twice the application security. Hawk’s acoustic wave transducers are self-cleaning and are used for...
continuous operation in dusty, wet environments where other technologies have caused process issues in coal prep plants. The power of each pulse (pressure wave) blows the water, moisture and build-up off the face of the diaphragm.

Coal sorting

Carl Bergmann, a Research Specialist at Mintek in South Africa says “sensor-based sorting is still a developing technology that is rapidly evolving. Improvements are continually being made in terms of sorter robustness and measurement sensitivity. “A very wide range of sensors are now available and in development and is predominantly represented by CommodasUltrasort. X-ray transmission sorting has particular promise in the field of dry coal sorting.” As well as the CommodasUltrasort product, Mintek is working with the Rados X-Ray fluorescence sorting technology, developed in Russia. CommodasUltrasort has introduced cutting edge dual energy X-ray (DE-XRT) technology capable of delivering separation efficiencies, it says, equal to conventional wet processing methods while reducing operational costs and enhancing downstream processing.

Most coal beneficiation plants use water intensive separation processes such as dense medium separation (DMS) or jiggng plants. In recent years, interest in dry coal separation technologies has gained momentum because water is becoming a scarce resource in many coal producing regions, also resulting in increased costs; dry coal has a higher heating value than wet coal; transportation of wet coal is more expensive and because of the costs involved in the environmental rehabilitation of coal slimes.

“With DE-XRT technology, no slurry is produced, resulting in reduced groundwater pollution due to acid drainage and salt accumulation in water circuits,” says General Manager Southern Africa CommodasUltrasort, Lütke von Ketelhodt. “DE-XRT technology is also less capital intensive because it does not require the extensive infrastructure and water handling requirements associated with dense medium separation. Another advantage is that de-shaled dry coal will burn more effectively than wet coal, which improves efficiencies when generating electricity in thermal power stations. DE-XRT sorting also enables pyrite removal, thereby reducing the sulphur content of the coal.”

DE-XRT technology is particularly suitable for the dry beneficiation of coarse coal in the size range -120 +50 mm at 150 t/h and -50 +12 mm at 80 t/h. Moisture content does not affect separation efficiency.
In South Africa, two contracts have been awarded to fully explore the benefits of this technology following successes achieved during a full production pilot operation at Arnot in Mpumalanga. The CommodasUltrasort PRO Secondary XRT sorter installed at Arnot handles 150-200 t/h of ROM coal for dry de-stoning and de-shaling. An up-scaling to 500 t/h or even more can easily be done by combining four of these units. As the installation requires electrical power only and little infrastructure, it can also be provided as a semi-mobile solution.

DE-XRT imaging conducts particle-by-particle sorting using a dual energy X-ray line-scan sensor, which generates images of the transmitted X-rays. The system allows for a rapid approximation of the atomic number range, which is used in combination with the high resolution image to evaluate mineral content and properties. Since DE-XRT does not involve surface layer detection, the technique is insensitive to surface coatings and dust.

Because shale and stone have a higher atomic density than coal, a density can be selected to determine if a particle should be regarded as coal or discard. In effect, this is organic versus inorganic separation, with coal being the organic component. Sulphur, in the form of iron pyrites, is also detected and discarded, thus reducing the sulphur content of the coal. Test work has shown that the DE-XRT sensor system can also distinguish between and separate different grades of coal at varying ash content criteria.

DE-XRT has proven effective not only for the de-shaling of coal and removing pyritic sulphur but also for separating coal and torbanite, which causes contamination at some of South Africa’s coal mines, adds von Ketelhodt. “A mix of coal and torbanite isn’t suitable for firing power stations or for export coal. However, this type of oil shale contains valuable smokeless fuel which can be pyrolysed and converted into liquid fuel. Since coal and torbanite have similar overall rock densities, separation technologies such as DMS or jigging do not work. Sorting on average atomic density, DE-XRT has proven able to separate clean coal from a shale/torbanite mix during the first pass, with torbanite and shale separated during the second pass.”

Tests on a 500 kg lignite sample collected in Texas also showed the effectiveness of DE-XRT in the removal of pyritic sulphides to produce clean power station lignite. With the separation of pyritic sulphides locked up in lignite, mercury levels have also dropped significantly. “With sensor based sorting technology gaining more and more significance in the mining and mineral process industry and the proven
For tensioned screen decks, Flex-Mat 3’s signature lime green polyurethane strips align to the screen box’s crown bars and hold individual wires in place as they run from hook to hook. Wear life exceeds that of woven wire up to three times because there are no cross wires with high wear spots like there are with woven wire, the company says. On modular screen decks, Flex-Mat 3’s modular panels install easily, similar to traditional polyurethane and rubber panels. On both screen types, Flex-Mat 3’s wires vibrate independently to better separate material, virtually eliminating blinding, pegging or clogging.

Screening
Major Wire says its Flex-Mat® 3 increases throughput. This high-performance, self-cleaning screen media helps solve rapid screen wear and blinding challenges in coal processing. Available for modular or tensioned screen decks, Flex-Mat 3 panels have more open area, providing up to 30% more screen capacity than woven wire and up to 50% more screen capacity than polyurethane and rubber panels. It employs independently vibrating wires that increase product throughput by up to 40% over traditional woven wire or polyurethane panels by increasing open area and eliminating any blinding, pegging and clogging. To date, says Major Wire, “Flex-Mat 3 has improved production and throughput in more than 20,000 aggregate, mining, recycle and coal applications worldwide.”

Clay content within coal can cause severe blinding problems for both woven wire and polyurethane, resulting in significant lost screen capacity and hours of downtime to clean the screens. Coal is also very corrosive and quickly wears out woven wire screens. Some producers increase the size of their woven wire screen boxes to increase capacity, but at great expense. Others shift to polyurethane panels for longer wear life; however, capacity is often greatly reduced in
exchange for the added wear life. By using Flex-Mat 3, producers can eliminate these problems while putting more spec product on the ground due to less downtime for cleaning or replacing screens—providing a greater return on investment without the need to make major screen box changes.

Flex-Mat 3 provides benefits on every screen box deck: eliminating near-size pegging on top decks, producing cleaner retained product through the middle decks and preventing fine material blinding on bottom decks. On modular screen decks, Flex-Mat 3 modular polyurethane panels can replace existing screen media on each deck wherever throughput is compromised or can replace the entire deck for maximum production.

Flex-Mat 3 tensioned is available in the industry’s broadest range of opening sizes — 595 micron to 102 mm — and with a wide range of application-specific wire diameters, enabling Major Wire to fine tune each screen’s production to its greatest potential. Coal’s corrosive properties, lead many producers to choose Flex-Mat 3 stainless steel wire for its tough wear characteristics. Depending on the spec product desired and the size of the original material, some producers choose either Flex-Mat 3 Series D or Series T (heavy-duty) configurations. Series D consistently produces accurate material separation, while Series T (heavy-duty) is used in applications with high material impact on screens. Series T for fine screening reduces blinding of very fine material.

Choosing flotation reagents

Flotation reagents are not an off-the-shelf product. They need to be carefully selected taking into account factors such as coal particle size and flotation equipment, which means the assistance of a reputable and experienced company such as MBE Minerals, official southern African distributor of EKOF Flotation of Germany.

Johannes Kottmann, Managing Director of MBE Minerals, says there is great scope for Ekofol locally, especially as mines are becoming more sophisticated in selecting flotation reagents for specific applications.

Ekofol is a combination collector-frothing reagent achieved an 8% higher recovery rate in laboratory and on-site testing in South Africa than local reagent, Kottmann says. He also notes that in Germany coal is extracted from depths of up to 1,200 m below surface and, for this reason flotation reagents are highly developed to optimise beneficiation and reduce production costs. “The emphasis in this market is maximum recovery without losing selectivity and Ekofol is used extensively in all German coal mines.”

The main advantage when using Ekofol flotation reagents is higher recovery rates. Ekofol is also 80% biodegradable, meaning added environmental benefits.

Kottmann says “MBE Minerals, through our association with EKOF, is able to offer a holistic solution encompassing both flotation equipment and reagents. It is the only company in the world able to offer such a package.”

The association with EKOF strengthens and complements MBE Minerals’ product offering which includes the Pneuflot® pneumatic flotation cell. EKOF has made steady inroads into such markets as China, India, Russia and Chile, and is now looking at consolidating its presence in the South African market.

Kottmann explains that Ekofol 440 is recommended for coals that can be floated normally. In addition to good collective characteristics, this product also exhibits a high degree of selectivity. For coals that can be floated more easily, the more economical Ekofol 452 and Ekofol 452G will produce good results.

For extremely fine-grain pulps and coal compounds that do not lend themselves well to flotation, Ekofol 440 and Ekofol 452 are well-suited. All these products can be mixed with gas oil, kerosene or tar-based oils (creosote), depending on the specific application.

The optimal combination of the kind of reagent and its quantity has to be determined in the laboratory in order to ensure satisfactory performance in the field. EKOF Germany undertakes intensive work with the flotation of various coal types and minerals to determine the best operational parameters.

Pneuflot cells suggest themselves for any application for which conventional agitator cells are used. Their design allows performance of the different tasks of the flotation process (pulp transport, particle suspension, small air bubble production and froth separation) in separate steps: The pulp is mixed with reagents in front of the flotation feed pump previously being aerated. While pumped to the cell, fine dispersed air is mixed into the flotation pulp by means of the patented aerator. The bubble/particle contact mainly takes place inside the aerator and partially in the descending pipe on their way down to the pulp distributor. The kinetic energy required for adhesion at the bubble/particle interface is generated by the turbulent flow of the pulp in the aerator.

The necessary flow rate and pressure is delivered by the appropriate slurry feed pump. The pulp distributor injects the aerated pulp in an upwards motion into the flotation vessel. The cell itself is only responsible for separating the remaining pulp from the froth formed by the loaded bubbles.

MBE Minerals says “the flotation period is no longer than the retention time of the pulp in the flotation vessel. It should amount to a minimum of two and a maximum of four minutes to allow the solids covered air bubbles an unhindered rising. Longer retention times of the suspension, i.e. larger flotation vessels, will in no case enhance the product quality because – contrary to the agitation cells – aeration has been terminated upon passage of the pulp through the aerator.

“Pneuflot cells are of simple design and are characterised by a particularly high yield in the froth product. This characteristic will be of benefit especially for relatively coarse solid particles. All drawbacks so far typical of pneumatic flotation cells, in particular gradual clogging of the aerating units, have been overcome thanks to the very modern materials, e.g. hard ceramics, both for pressurised units and for self-aerating units. Fears of rapid wear due to the relatively high pulp velocities in the aerating units or the deflecting distributor have not been justified.

“A particular advantage of self-aspirating aerators is the very low demand of electrical energy which is no more than that of the feed pump. In view of the fact that the purity of the solid product discharged with the froth is significantly better for Pneuflot cell types than for agitation cells, one or even several secondary cleaning stages are not necessary. They are an absolute must for agitation cells, especially for materials of poor floating properties.”