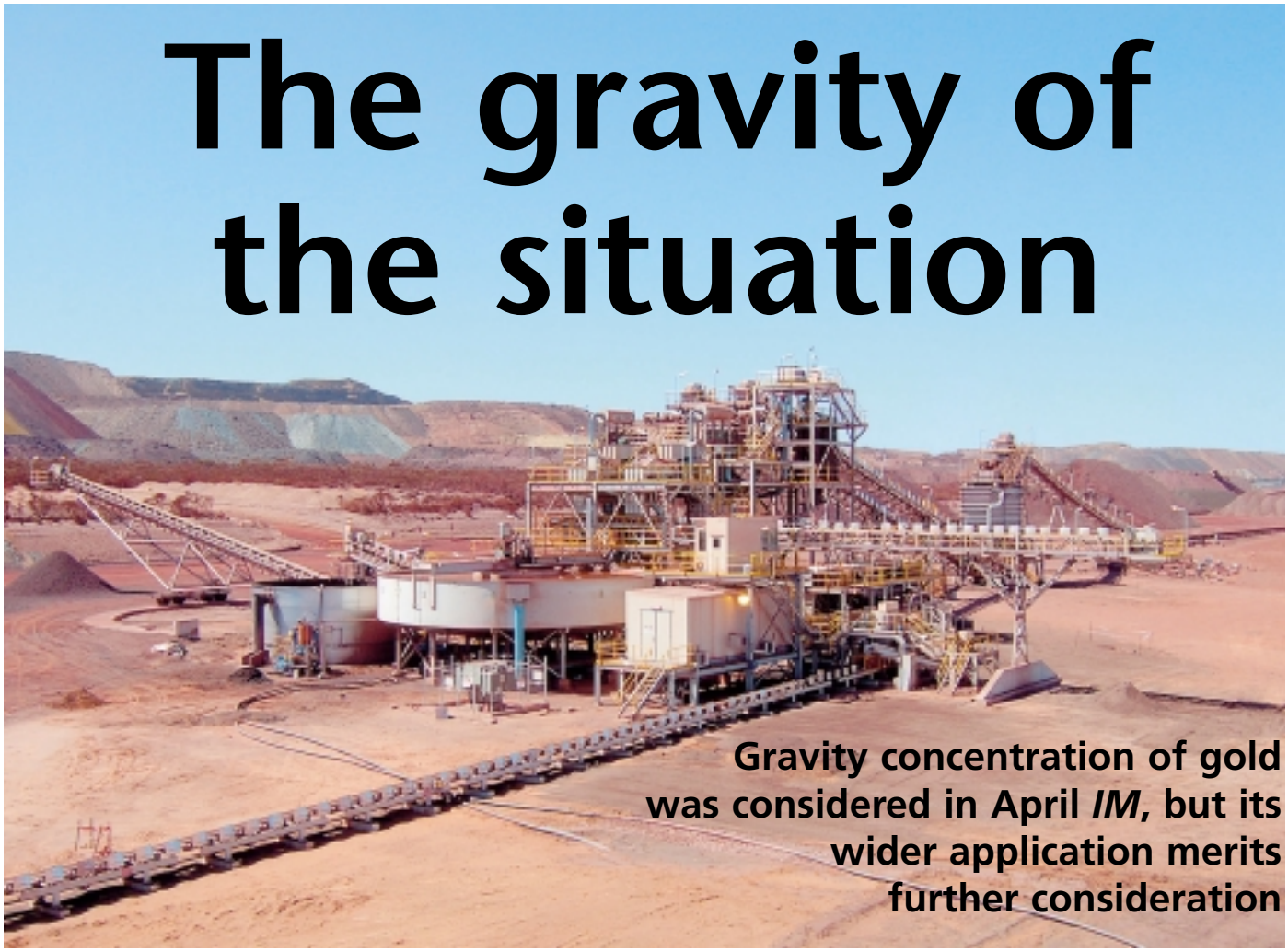
The gravity of the situation



Gravity concentration of gold was considered in April *IM*, but its wider application merits further consideration

An alljig installation in Australia.

Gravity concentration is re-establishing its importance, which has been known since ancient times, mainly for cost and environmental reasons. Outokumpu technology notes "a traditional application of gravity circuits is the recovery of gold from placer deposits. However, gravity concentration is finding innovative applications in gold processing due to significant advances in equipment design, simplicity, lower operating costs and increased environmental concerns." For example gravity technology can be used:

- As a preconcentration step in conventional leach circuits
- To recover coarse gold from grinding circuit classifier underflow – can reduce losses of this material in the leach step, thereby increasing overall recovery
- To recover gold-bearing pyrite concentrates from sulphide ores. The gold can then be extracted following roasting or other pretreatment methods
- The highly selective operation of enhanced gravity concentrators can recover free gold from flotation concentrates.

The latter includes Outokumpu Technology's Floatex density separator, which offers:

- Sharp separation of particle sizes
- High capacity units
- Reliable and simple operation
- Automated control system

Outokumpu Technology notes "inherent advantages" of minimal or no reagent costs, minimal energy costs, ease of operating and maintaining the equipment and low labour requirements in gravity concentration using equipment such as spiral concentrators, tables, and the Floatex units. "Dry electrostatic equipment is also available for recovery of precious metals from slags."

Spiral concentrators consume no reagents or power and offer high upgrade ratios. Tables also consume no reagents, and low power, offering close control of product grade and high recovery.

Centrifugal jig

Since the first commercial Kelsey Centrifugal Jig (KCJ) unit was installed at the Renison Bell tin mine in Tasmania, Australia in 1992, the KCJ has found many applications in tin, tantalum and mineral sands. The KCJ is now one of the many gravity processing technologies offered by Roche Mineral Technologies, and with further development and improvement in hardware (including such things as an automatic screen cleaner) and introduction of the high-capacity Model J1800 KCJ, the KCJ has also been installed and/or found application in other industries, such as gold, nickel, iron ore, chromite and base metals.

The KCJ has the capability to achieve high separation efficiency (i.e. high recovery and concentrate upgrade in a relatively small mass) because it separates minerals based on their specific gravity (as opposed to centrifugal concentrators, which separate minerals on the basis of their mass). This can represent a significant advantage in terms of downstream processing of relatively small concentrate tonnages. In order to take advantage of these metallurgical benefits, it is important to establish and maintain the correct circuit around the KCJ, as depicted in the schematic flowsheet.

Over many years of operation in various applications, it has clearly been identified that the most successful KCJ installations are those which establish and maintain such a circuit and

in particular focus on optimization of:

- Feed classification
- Ragging material classification and recovery
- Hutch water quality, flow rate and pressure
- Solids feed rate

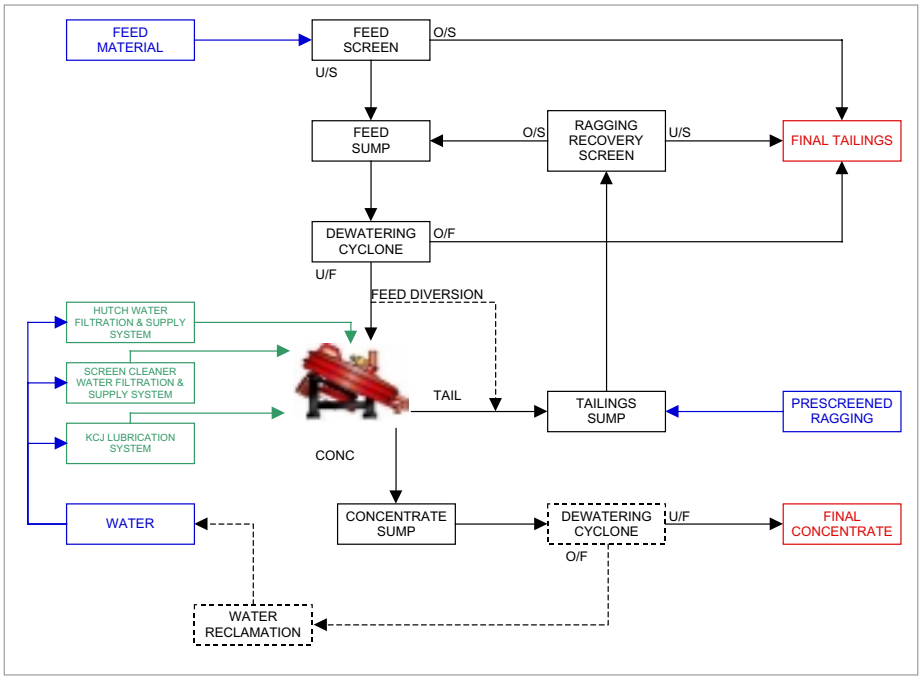
In relation to these issues, Roche have undertaken significant development work on the design of compact and relocatable packaged plants that incorporate all essential ancillary equipment for a successful KCJ installation. An initial version of such a relocatable plant is shown in the picture, incorporating two KCJ1800 units and two Derrick Stack Sizer screens.

Further development work has culminated in the design of a compact package plant incorporating one KCJ1300 unit and a Derrick Stack Sizer screen contained in standard shipping containers. This modular plant design has also been used in the design of a relocatable plant incorporating one KCJ1800 unit and a Derrick Stack Sizer screen, which is available to clients for on-site trials in the form of a pilot plant.

Over the last 18 months, Roche has undertaken a significant amount of work on the development of efficient tungsten ore processing flowsheets for a number of Australian applications. The two most common and industrially important tungsten minerals are scheelite [$CaWO_4$] and wolframite [(Fe, Mn)WO_4], both of which are generally mined underground and then crushed and milled. Often, further processing will then involve some form of gravity separation and (for scheelite) flotation or (for wolframite) magnetic separation in order to produce a final concentrate grade >65% WO_3.

One application involving Roche is the pre-concentration of finely ground scheelite minerals with the KCJ (at high recoveries into a relatively small concentrate mass, while rejecting the majority of the gangue minerals), followed by wet high intensity magnetic separation (WHIMS) to remove heavy, paramagnetic minerals (such as garnet and pyrite). The resultant non-magnetic scheelite concentrate is then subjected to final cleaning in a much smaller sulphide and scheelite flotation circuit (than would be required on the whole-of-ore material) which operates more effectively in the absence of gangue minerals such as calcite.

The results illustrate the effectiveness of the KCJ in pre-concentrating ~80% of the scheelite minerals present in the feed into a concentrate mass of ~20% of the feed, while rejecting >90% of the (CO_3) calcite gangue minerals. Of particular note is the very high WO_3 recovery in the 18-75 µm size fractions. Decreased WO_3 recovery from the +75 µm size fraction is known to be due to the rejection of coarse composite scheelite particles, which would be captured in a scavenging/regrinding stage, while decreased WO_3 recoveries from the -18 µm (and in particular the -9 µm) size fractions are due to a decrease in separation efficiency between scheelite and gangue minerals which would be minimized through optimization of grinding performance to prevent the generation of excessive ultra fine scheelite.



With recirculation of appropriate streams (containing composite scheelite particles) and optimization of the grinding process, it is expected that overall recovery from the gravity circuit will exceed 90% WO_3. Magnetic separation of KCJ concentrate, using WHIMS, also proved very successful, with >95% of the scheelite being recovered into ~50% of the feed mass. Work is continuing on the development of a final flowsheet and plant design to bring this project to fruition.

Another application involves scavenging tungsten (mainly wolframite) minerals from a Mo/Bi flotation tailings stream. The KCJ can very efficiently recover >95% of the WO_3 into <15% of the feed mass. In fact, from the +125-180 µm size fraction, ~97% of the WO_3 was recovered into ~1.2% of the feed mass. While recovery of WO_3 from the finer size fractions remained very high, some loss in separation efficiency between wolframite and gangue minerals was experienced due to fine gangue mineral tracking to concentrate through ragging interstices set at a size to also cater for recovery of larger particles. However, overall rejection of SiO_2 to tailings was still in excess of 85%.

In order to take advantage of its metallurgical benefits, it is important to establish and maintain the correct circuit around the KCJ.

This work culminated in the sale of a compact package plant incorporating one KCJ1300 unit, feed and ragging classification and other ancillary equipment, such as pumps and sumps, to the project. Flowsheet development is currently continuing on a cleaning circuit incorporating low intensity magnetic separation (LIMS) and WHIMS (to remove further silicate and iron carbonate gangue minerals), classification of the WHIMS magnetic steam and further gravity concentration of the coarse (with tables) and fine (with a KCJ) fractions from classification.

Iron ore success

For the wet separation of primary and secondary raw and waste materials, more than 300 alljigs® are in operation worldwide for efficient separation and beneficiation of coal, ores and slags. The allair®-jig offered by allmineral is another effective instrument for dry processing of coal and lignite - 37 machines of this type are already in operation worldwide.

The Sishen Expansion Project (SEP – ***IM*** September 2006 Operations Focus) is becoming quite a success story for allmineral. Initially Kumba Resources ordered 18 alljigs from allmineral in October 2005, and then ordered an additional 6 alljig systems. The systems from the first order were delivered in September 2006, and the second was being delivered this spring.

Integral to the SEP, allmineral's state-of-the-art technology is producing quality iron ore

from material that was previously considered waste. The high-performance alljig machines guarantee an export quality of 64% Fe, even with graded products containing only slightly more than 50% Fe - this has opened up additional mining potential.

"Although the current life-of-mine is estimated at ~25 years, the additional 300 Mt, some of which was previously stockpiled, can now be beneficiated to a saleable product" states Udo Busch, the head of the allmineral subsidiary in Johannesburg.

Technical data of the 24 alljigs supplied to the SEP:

Coarse Jigs - eight alljig® G(UB)-4000x 3000 for iron ore at 8-25mm feed size
Capacity: 320t/h
Jig length: 3 m and jig width: 4 m
Number of chambers: three

Medium Jigs - eight alljig® M(UB) 3500x3000 for iron ore at 3-8mm feed size
Capacity: 165t/h
Jig length: 3 m and jig width: 3.5 m
Number of chambers: three

Fine Jigs – eight alljig® F(UB)-2200x3000 for iron ore at 0.8-3mm feed size
Capacity: 60t/h
Jig length: 3 m and jig width 2.2 m
Number of chambers: three

At the beginning of 2007 allmineral extended its product line to include a high-intensity magnetic separator. "The GAUSTEC® magnetic separator," allmineral reports, "is mainly of interest to customers who intend to separate fine particles including inter grown ores and minerals according to their respective magnetic properties." This new product was covered in the German Technology article in April ***IM***.

Outokumpu Technology says its high-tension electrostatic separators are ideal for precious metals refinery slags. When smelting to refine gold or silver, a slag is produced that can contain 'prills' of precious metals. When the slag is crushed, the metallic values become liberated and amenable to electrostatic separation. Dry electrostatic separation treatment of slag has special requirements. These include automated electrode cleaning, dust extraction and roll brushing. The company notes customers reporting typical recoveries of metallic values of +95%.

It says the benefits of electrostatic separation of precious metals slags include a dry process concentrate that can be returned directly into the furnace, reducing in-house and in-process precious metals inventory.

Normally raw slag is crushed and sized at 20 x 100 mesh. Coarse metallic values are captured on a 6-mm screen. For large capacity (+5,000 t of slag per week) operations, a two-stage electrostatic separator is recommended. A single-stage unit can be used for refineries with smaller slag production. Metal concentrates are returned to the furnace. Middlings are recrushed while the tailing can be leached.

Johan Engelbrecht, Managing Director of Multotec Process Equipment, notes increased coal prices have resulted in the retreatment of dumps and lower-grade deposits, and this has necessitated a different design in cyclone. Traditionally, cyclones were controlled by the quantity of sinks or rejects that could be handled when treating these lower yield feeds. So, Multotec, a global leader in the design and application of dense media cyclones, is launching a new improved design specifically aimed at the coal sector. Developed in conjunction with a major university, this dense media cyclone has higher spigot or apex capacities.

An initial version of a movable centrifugal jig plant, incorporating two Roche KCJ1800 units and two Derrick Stack Sizer screens.

"As a company that is actively involved in research and development, we have been exposed to varying and difficult coal types in South Africa, which has led to cyclone designs with improved efficiencies," Engelbrecht says. Some of the specially adapted features on Multotec dense media cyclones include longer barrel sections where misplaced materials are reduced by as much as 30%. "In terms of bottom-line savings and the impact on profitability, this is a substantial benefit for most mines," he says.

"However, in order to exploit the advantages of the longer barrels fully, the design of the total system must be taken into account as well. This includes density control with the distribution system involved as well as the properties of the magnetite media," he continues. With the introduction of large-diameter cyclones, larger top-size particles can be treated, with a consequent impact on the wear rate.

Construction materials have also paralleled developments in process technology. "At present the move is away from the traditional Ni-Hard and high-chrome cast iron materials to the more exotic ceramics such as alumina and silicon carbide. The current preference in the industry for lining a cyclone is to use 25-mm-thick high-alumina ceramic engineered tiles due to the cost-effectiveness. It is important that these tiles are engineered properly, as their wear life is only as good as the joints. Therefore the actual manufacture of these tiles, and their installation, are critical factors in maximizing wear life," Engelbrecht says. Practical operations have shown that properly engineered and installed tiles can provide up to double the life of hand-cut standard tiles.

"Multotec has been fortunate in having a large local base of heavy media applications. This involves processing of diamond ores, iron ores, manganese ores and andalusite ores, as well as some chromite ores, through dense media cyclones. The need for very high cut densities in the range of four necessitated our involvement in the whole circuit, especially densification, where we have developed a couple of solutions in terms of densification and cleaning of the media," Engelbrecht says.

Another recent development is a unique high-intensity

magnetic drum separator, which not only improves the densities attainable in densification, but also minimizes the losses of the expensive ferrosilicon. This is in line with Multotec's mission statement to get involved in the entire process so as to give the customer the added benefit of our full spectrum of process knowledge.

DMS for Alrosa

Dense Media Separation (DMS) is seeing wider applications in different metals as well as its more traditional applications in diamonds and coal. DRA is one engineering company that does many such plants and one of its latest is a $2 million order from the Russian diamond miner Alrosa for three modular DMS plants for alluvial operations in the Republic of Yakutia in northern Siberia, near the Anabar River. The first modular plant was shipped in December last year and the remaining two in February 2007.

The 55-65 t/h capacity plants are compact enough to fit into open top containers while still allowing ease of access for maintenance. The logistics of the project were difficult: the plants were shipped to St Petersburg, railed to Urkutsk, 6,500 km to the east, and then trucked north along frozen rivers into the Arctic Circle. Here they were commissioned on site using local labour under DRA supervision via a Russian interpreter.

Operations in this region are restricted to about 100 days a year in summer, due to winter temperatures of –50°C or below. Even in midsummer, temperatures may stay below –10°C. Such conditions require low temperature lubricants and special conveyor belting, cabling and switchgear. Plug in cables are used for the power supply to avoid making cable connections onsite. In winter, with the plant shut down, equipment liable to get damaged in the extreme cold is removed and placed in relatively warm storage.

This is DRA's third venture in the area which started with a single 50 t/h DMS plant at Estok in 2004. It was followed a year later by the supply of two 55-65 t/h units for a kimberlite pipe operation at Aykhal as a replacement for part of the jig section at the existing plant. ***IM***