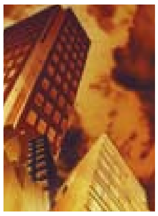

CSIRO

CSIRO research in minerals processing and metal production OCTOBER 2006

PROCESS

ALTERNATIVE FUEL

Closing a King-sized loop

Harvesting kelp on King Island.
PHOTO: RICK EAVES

By SUE NEALES

FINDING alternative fuel sources on a small remote island, such as King Island in Bass Strait, loomed as a big problem for industrial seaweed processor Kelp Industries.

The supply of old wooden fences and dead trees used to heat its furnaces to temperatures in excess of 1000°C was not going to last forever.

But shipping in liquefied petroleum gas (LPG) or diesel to run generators to heat its seaweed drying kilns was simply too expensive.

And with King Island, halfway between Tasmania and Victoria, fast building a reputation as a producer of high-quality fresh and pure foods, environmental considerations were also an issue.

That was when the island's two main industries – Kelp Industries and the famous King Island Dairy, now owned by National Foods – put their heads together.

Kelp Industries general manager John Hiscock recalls the first brainstorming session: "We had a fuel problem and they had a cardboard problem. The dairy had mentioned how much waste cardboard they had that was too expensive to ship back to the mainland, and was wondering how else they could use it on the island.

"Then I remembered the briquettes made from cardboard I'd seen for sale in a shop somewhere."

And so the bright spark of an idea to recycle King Island's excess cardboard packaging into dense briquettes to help fuel the kelp furnaces and drying kilns was born.

Key points

- Recycled cardboard is partially fuelling the kelp furnaces and drying kilns on remote King Island, conveniently using King Island Dairy's unwanted packaging
- The optimal proportion of the housebrick-sized cardboard briquettes is 30 to 50 per cent of the fuel mix
- CSIRO resolved briquette density issues, the optimal ratio of cardboard to wood and conducted ash analysis to ensure the cardboard did not contaminate the seaweed

With the support of the local King Island Council, the next challenge was to check if the theory

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Inside

CSIRO
Process

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COMMENT

DR BART FOLLINK
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Energy-efficient minerals processes

With petrol prices in Australia hitting all-time highs recently, it is not surprising that energy and fuel consumption have become hot topics of discussion for many of the nation's motorists. It is not just road users that have to foot the bill, though. Industry – in particular heavy industry, such as minerals processing – is also hard-hit by developments in the oil economy.

Energy reduction in minerals processing has two distinct but synergistic elements: keeping the minerals industry economically competitive is absolutely essential, but environmental considerations, such as greenhouse gas emissions, are also increasingly important.

For sustainable and vibrant minerals activity to persist in Australia, a minimal environmental footprint along the entire value chain is crucial, from exploration, mining and processing right through to goods manufacturing.

The Exploration & Mining and Minerals divisions of CSIRO are working on these issues and, by way of introduction, I happily refer to the column on page 11 by Dr Peter Lilly, Exploration & Mining's new chief.

Many of the activities in CSIRO Minerals explicitly focus on the reduction of environmental impact while optimising productivity. Minimising water usage and energy reduction are obvious areas to start with in an Australian setting. In both of these areas we have sizeable research and development activities in place.

This issue of *Process* provides a taste of some of the creative work of our researchers in the energy-saving domain. Our work with King Island demonstrates how answers can be found when a creative and cooperative spirit is brought to bear on a problem.

As we state in our mission: we are here to work with industry and the community to optimise wealth from minerals reserves while drastically reducing environmental impact.

Expect more from us in the environmentally sustainable processing domain.

Closing a King-sized loop

FROM PAGE 1

was scientifically practical. Economic feasibility studies would come later.

As an expert in furnaces and briquetting, CSIRO Minerals principal research scientist Bob Flann was called. He relished the challenge of helping the community solve its problems – and to neatly close a processing loop.

"It was a project from left field with a natty solution, and I really liked the idea that CSIRO could assist the island people in facilitating a good outcome," Mr Flann says.

The first step was to fly to King Island to inspect the furnaces being used by Kelp Industries and the type of spare cardboard available.

Key scientific elements that CSIRO needed to resolve were the correct density of the cardboard briquettes for use in the furnace, the optimal ratio of cardboard to wood burning to sustain the process and ash analysis to ensure impurities from the cardboard did not contaminate the drying seaweed.

An added complication was that although the kilns only needed a heated airflow of about 70°C to dry the seaweed before it was exported for alginate extracts, the furnace needed to reach 1100°C to ensure the drying air was free of contaminants.

One year later, after a trial of 300 kilograms of briquettes made by CSIRO Minerals in Melbourne and shipped to Kelp Industries on King Island, the results are scientifically clear.

Solid briquettes – the size of a housebrick – made from shredded cardboard waste work well in Kelp Industries' furnace as a 30 to 50 per cent component of the total fuel mix.


PHOTO: RICK EAVES

Extensive analysis established that potential contaminants such as arsenic, lead, cadmium and mercury in the dried seaweed were negligible, although Mr Flann recommends that only plain cardboard with minimal colour is used.

"It's been a really satisfying project, both technically and in being able to help the community so practically and in two such important ways," Mr Flann says. "There are still financial aspects of the project to be resolved, but it has been a great example of how applied technology developed in the coal industry can assist a remote community."

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WASTE HEAT RECOVERY

Identifying and recovering heat energy

A RECENT review by the Energy Transformed Flagship highlights the potential for substantial energy savings through recovering waste heat, and recommends using satellite technology to map the nation's hot spots.

The high-temperature processes used in producing commodities such as alumina, base metals, iron, steel and cement generate waste heats in various forms, including off-gases, liquids and solids. Many operators have implemented some form of waste-heat recovery system for high-grade energy (greater than 500°C).

But according to CSIRO Minerals research scientist Dr John Sanderson – who led the review project – little is being done to recover low- to medium-grade waste heat, which accounts for more than half of the total heat generated in industry.

"Capturing this energy could help the industry improve its environmental performance and realise substantial energy savings," he says.

The flagship's comprehensive review of waste-heat recovery technologies has identified practical opportunities for additional recovery within key mineral processing industries. Some technologies, however, need adaptation to suit the harsh environments of these operations.

The review also identified the need for mapping key waste-heat emission hot spots in Australia.

"We've been working with CSIRO Land and Water to investigate the potential of their thermal imaging data processing in this area," Dr Sanderson says.

Derived from NASA's MODIS (Moderate Resolution Imaging Spectrometer) satellite data, the technology was originally developed to assist with bushfire monitoring.

"It's a reasonable assumption that thermal imaging data could be used to identify large waste-heat emissions from all industry sectors, not just minerals processing," Dr Sanderson says. "Developing a national picture of waste heat emissions would allow us to identify those areas with high waste-heat recovery and electricity generation potential."

The review recommends a pilot study of the MODIS technology and its application to the minerals processing industry, as well as further research and development to improve existing heat exchangers and heat cycles.

"We are also seeking early industry involvement to support the development of improved heat recovery concepts," Dr Sanderson says.

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SLAG GRANULATION

The heat is on

Researchers are working on a technique to recover waste heat from molten slag using dry granulation, with important economic and environmental outcomes for the iron and steelmaking industries.

A plant producing one million tonnes of steel a year also produces 300,000 tonnes of slag. On cooling from 1500°C to 200°C, these molten slags release about 0.4 peta joules of high-grade heat – the same amount of energy needed to power 8000 homes.

Dr Dongsheng Xie, CSIRO Minerals project leader, says: "The heat is currently lost through water granulation of the slag, which also uses enough water to fill 120 Olympic-sized swimming pools, and can potentially lead to pollution problems, such as acid mist generation."

One emerging technique – dry slag granulation – potentially offers an ideal solution.

The technique involves using a dry process to break the molten slag into fine granulates. It provides optimised conditions for efficient heat recovery and rapid air quenching, producing glassy granulates that are a valued feed for cement manufacture.

"Dry slag granulation allows for efficient heat recovery from molten slags and minimises water usage and pollution," says Dr Xie. "Using the slag granulates in cement also delivers significant greenhouse gas and economic benefits."

The dry slag granulation technique, first reported in Europe and Japan in the 1980s, has been extensively tested in laboratory and plant trials but has yet to be commercialised.

"CSIRO has made significant improvements in process design and control," says Dr Xie. "Our work will continue through two new projects funded by the iron and steel industries and the Centre for Sustainable Resource Processing."

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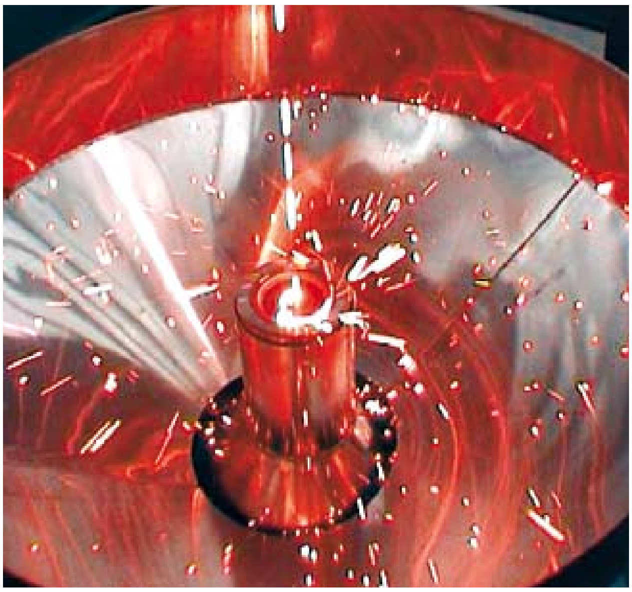

CSIRO's dry granulation process: molten slag pours on to a rotary disc.
PHOTO: STEVE SANETSIS

Ivan Kekic installing the UltraPS probe in a slurry tank.
PHOTO: TIM TAPSELL

ACOUSTIC ANALYSERS

Good vibrations

By REBECCA THYER

THROUGH technology that deploys acoustic waves to monitor machines and procedures, operators of minerals processing facilities could soon be able to 'hear' how their machinery is performing.

The 'ears' developed by researchers at CSIRO Minerals are a range of on-line analysers that use active and passive acoustic waves to cut through background noise generated by masses of heavy machinery.

CSIRO project leader Michael Millen says effective on-line analysis is vital for the minerals processing industry. "It provides industry with the ability to rapidly respond to changes in processes or machine condition, allowing operators to optimise processes, minimise downtime, maximise efficiency … and save money."

CSIRO's UltraPS and Acoustic Emission (AE) analysers both use acoustic waves to analyse processing conditions. The UltraPS analyser uses active acoustic waves at ultrasonic frequencies to measure the size distribution of solid particles in mineral slurries. The AE analyser monitors passive acoustic waves at frequencies in and above the human hearing range to sense the condition and state of processes within noisy processing machines.

Active waves are generated by the analyser to inject into slurries or materials, whereas passive acoustic waves are naturally generated within machinery or objects containing moving parts or within material by particle impacts, friction, fluid flow and bubble collapse.

These elastic waves move through a device and can be sensed outside.

The UltraPS analyser has been developed specifically for use in grinding circuits where "under-grinding results in poor separation and over-grinding results in energy wastage," Mr Millen says. "Getting it right is important because a grinding mill is the biggest single energy user on a minerals plant."

The analyser sends pulsed acoustic waves through the slurry and monitors transmitted sound vibrations to derive particle size distributions.

It takes less than a minute to analyse conditions and can operate in undiluted opaque slurries at very high solids concentration.

The standard model is working in a number of mineral processing plants in Australia and South Africa and research is well advanced to develop a version to monitor multiple slurry streams, Mr Millen says. A version for alumina refineries is also under development.

CSIRO's AE analyser also monitors acoustic waves to assess processing units' operation and wear state, in equipment such as dense medium cyclones.

It monitors acoustic waves generated by particle strikes on a cyclone's internal walls, which are picked up by sensors mounted on the outside shell.

CSIRO Minerals researcher Dr Steven Spencer says modern statistical analysis techniques are then applied to extract information such as separation efficiency and the condition (wear state) of the cyclone 'liners'. Obtaining this information takes less than 10 seconds and the analyser's robust sensors do not need to be inside the processor.

"It is expected to have wide application in many industrial processes where noise in and above the audible frequency range is influenced by process and machine condition," Dr Spencer says.

The technology has been tested at coal preparation plants as part of an Australian Coal Association Research Program project. The team aims to develop a commercial prototype for these plants.

In addition to cyclones, CSIRO is developing an AE analyser for autogenous and semi-autogenous grinding mills.

Dr Spencer says the ability to cheaply, non-intrusively and continuously monitor variables and wear states in enclosed processing vessels is significant: "The potential increase in process throughput and product quality, coupled with a decrease in shutdown maintenance costs, could translate into substantial cost savings."

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ON-LINE ANALYSIS

Turning up the heat on energy savings

By YOUNA ANGEVIN-CASTRO

WITH growing social pressure on the minerals and coal industries to develop environmentally sustainable production methods, CSIRO Minerals has developed a new technology that addresses environmental concerns and also generates positive economic outcomes for industry.

The on-line analysis technique is called Neutron Inelastic-scattering and Thermal-scattering Analysis (NITA) and has the potential to create significant energy savings for the coal industry.

With valuable repercussions in processing efficiencies, on-line analysis instruments are becoming increasingly important to the industry. They can be used to measure mineral values on the production line without having to take samples, and can improve productivity by providing continuous data in real time – optimising processes, minimising downtime and maximising efficiency.

NITA works by firing neutrons at the target material – for example, coal – and measuring the gamma rays emitted during the process. Dr Cheryl Lim, a researcher on the NITA project, says energy consumption in the mining and mineral processing industries is linked to how well processes can be monitored. "From a generic perspective, all on-line analysis technology can help control and optimise energy consumption.

"More specifically, NITA's ability to determine elemental composition means we can use it to assess coal quality, based on measures such as ash content. In power stations, for example, coal is burned on the basis of how much energy can be extracted. Knowing the quality of the coal will affect how to run the burner and reduce energy wastage."

The ability to screen large volumes and operate in hostile environments means that NITA has wide applications. As well as coal analysis, the technique has been used to monitor reactions in furnaces for pyrometallurgical applications and to control blending of raw feed in cement manufacture and has huge potential in processes involving slurries.

With funding and support from the Australian Coal Association Research Program, an analyser based on the NITA technique has been constructed and is undergoing demonstration in an Australian coal preparation plant. The analyser should be capable of measuring ash independent of changes in segregation, belt loading and composition.

Laura Noack loading a sample for measurement. PHOTO: TIM TAPSELL

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Samples

Self-healing metals

CSIRO Manufacturing and Materials Technology (MMT) researchers are investigating metals that incorporate self-healing mechanisms. A self-healing metal's secret is its combination of alloying elements and exposure to heat treatments that create a metal which is capable of internal changes triggered by loading conditions. When areas of fatigue or stress appear, high free-energy sites are created. The alloying elements move to these sites, emerging from solution as small crystallites to fill or repair the crack. Researchers have had success with some experimental alloys and are homing in on optimum processing conditions.

MARK FERGUS

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Pipeline transport

Hydraulic conveying systems may provide a key to water conservation for the mining and processing industries. These systems are moving towards higher solids concentration, reduced water to tailings, higher stability of the tailings discharge and the ability to co-dispose of coarse overburden with the processing fines. CSIRO MMT has developed a unique tilting pipeline test loop facility that can consider flows at any pipe inclination angle from horizontal to vertical. This has opened up the possibility of using high-concentration conveying for 'vertical hoisting' of ore out of mines, eliminating the need for expensive road haulage.

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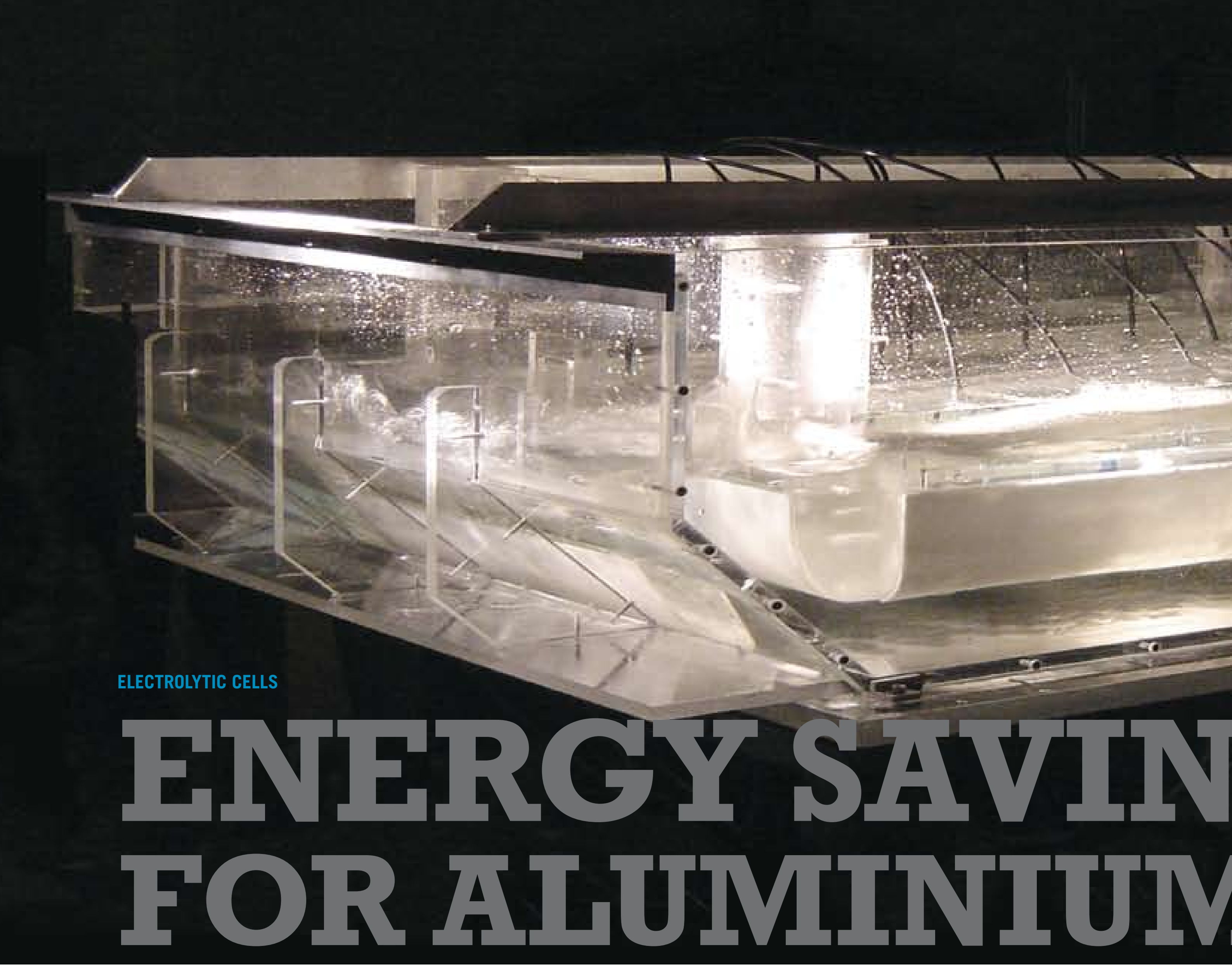


ELECTROLYTIC CELLS

ENERGY SAVIN FOR ALUMINIUM

By TONY KAYE

AUSTRALIA is at the forefront of research to reduce energy consumption in primary aluminium production, with researchers focusing on a revolutionary electrolytic cell technology.

About 30 million tonnes of aluminium are used worldwide each year and demand for the metal is steadily increasing, with growth averaging between two and four per cent a year. But while increased aluminium sales are good on one level, paradoxically, there are also negatives to higher production.

Aluminium production is one of the most power-hungry of the metal production industries. It accounts for more than 10 per cent of Australia's total power consumption, making the industry the single largest electricity consumer in the country.

Energy-saving efforts centre on drained cathode cell (DCC) technology, which for many years has been recognised for its potential to significantly reduce the power consumption costs of aluminium production. DCC facilitates operation at a lower anode–cathode distance, resulting in lower electrical resistance and therefore reduced energy demand.

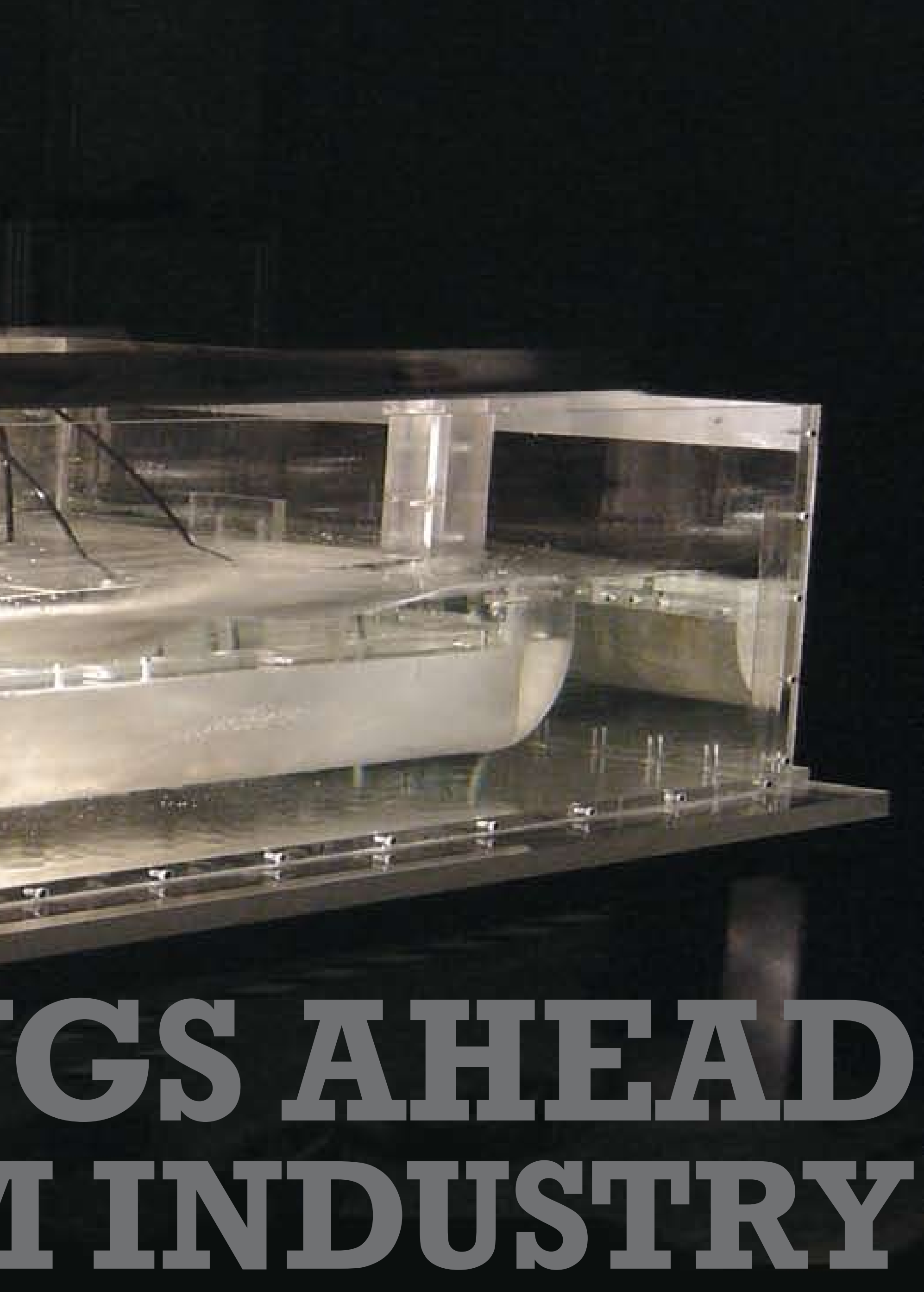
Comalco Aluminium, one of Australia's largest aluminium producers, has been developing and testing drained cathode cells and now aims to resolve the final impediments to the technology's commercial application.

The company is working with scientists from the Light Metals Flagship, a CSIRO-led national research initiative that brings together science and industry to tackle key challenges.

"The technology provides a range of opportunities to fundamentally change the way an aluminium cell functions," says Greg Hardie, manager of the DCC Project at Comalco. "The enhanced capabilities can be utilised in different ways to overcome the barriers to reducing energy consumption and increasing productivity inherent in conventional cell designs.

"This will be a significant step-change for the industry in its own right and a key enabler for future developments such as inert anodes if it is successful. We are expecting to achieve electrical energy savings of at least 10 per cent in the new prototypes about to be tested."

The aluminium production process is crucial to the energy issue. It starts with the mining of bauxite ore, of which Australia has abundant supplies. Once mined, the bauxite is refined to produce alumina. The alumina is then



Water model of DCC used for PIV measurements.
PHOTO: WILLIAM YANG

taken to aluminium smelters, where it is dissolved in an electrolytic solution (cryolite) at 960°C in hundreds of large steel furnaces lined with refractory bricks and carbon cathhodes.

These furnaces effectively become electric cells when a current is passed down through the cryolite from a carbon anode (positive electrode) to a carbon cathode (negative electrode).

The electrolytic reaction reduces alumina to aluminium, and the resultant molten aluminium is siphoned off to a holding furnace, from where it is processed and cast.

To reduce the amount of energy used in the process the required solution is to reduce the distance between the anode and cathode in the cell and reduce cell heat loss. With less distance to travel through the electrolyte, the electrical resistance and energy consumption can be reduced.

However, the strong magnetic

CONTINUED PAGE 8

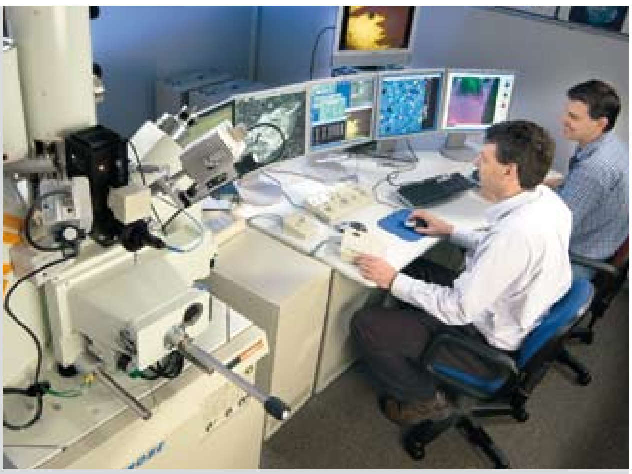
HyperProbe

CSIRO Minerals has recently purchased a new state-of-the-art electron microprobe, known as a HyperProbe, from JEOL. It is the only one of its type in the world and is ideally suited to handling some of the unique problems encountered in mineral processing.

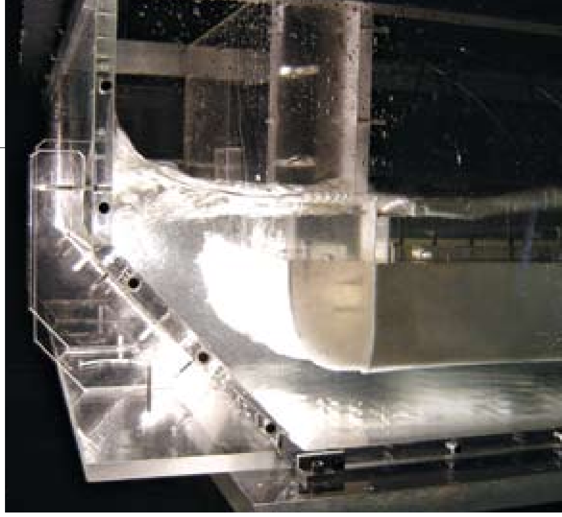
The instrument has a high-brightness field emission gun, which can perform trace element analysis in sub-micron regions at high speed.

Mapping capabilities will be significantly enhanced by the combination of five wavelength and two energy dispersive spectrometers. Light element detection will be enhanced by new crystals optimised for beryllium, boron, carbon, nitrogen and oxygen. A plasma cleaning system is built into the air interlock enabling cleaning of sample surfaces prior to insertion in the main chamber. This significantly reduces organic contamination and will enable detection and quantification of low levels of light elements.

Light Metals Flagship project leader Mark Cooksey says the HyperProbe will be in high demand. “The purchase of the HyperProbe helps CSIRO Minerals maintain its position at the forefront of materials characterisation capability, which is why industry looks to us for assistance.”



Colin MacRae and Nick Wilson operating the HyperProbe electron microprobe used for measuring trace element distributions.
PHOTO: MARK FERGUS



Energy savings ahead for aluminium industry FROM PAGE 7

fields in the cell cause waves to form in the pool of molten aluminium. If the anode–cathode distance is too small, the aluminium may form a short circuit by contacting the anode, or it may reoxidise by contacting carbon dioxide gas evolved in the electrolytic reaction. Either of these processes will reduce aluminium production.

The use of drained cathode cells will help to address this problem. Comalco has been researching and developing wettable cathode technology that uses a titanium diboride/carbon composite coating. Titanium diboride has a number of special qualities, including its ability to be wetted by aluminium, high electrical conductivity and low solubility in aluminium and cryolite.

The cathode coating technology has demonstrated its potential for increasing the life of cells and making the drained cathode cell design commercially viable.

Research involving computational fluid dynamics and physical modelling is under way to better understand metal, electrolyte and gas bubble movement in the cell, and CSIRO is also applying its materials expertise to help improve the titanium diboride composite.

Another CSIRO team is developing an advanced coating technology to protect the cathode during cell start-up. It is expected that these developments will help to increase the life of the composite in the cell.

"The skills base required to successfully bring a new smelting technology to commercialisation is generally beyond a single organisation to build and maintain," Mr Hardie says. "The involvement of CSIRO is crucial because of their cutting-edge capabilities in physical and mathematical modelling and materials science. We look forward to working with CSIRO and building the combined team capabilities to rapidly address the technical challenges confronting this complex undertaking."

Light Metals Flagship project leader Mark Cooksey says computational fluid dynamics and physical modelling help in making design decisions.

"A cell has a lifetime of several years, so it is expensive to conduct trials on the real process. We now have computer models of these cells, so we can model different designs more rapidly and cost-effectively.

"Comalco is now using the results of our modelling to help decide on future cell designs."

According to Mr Cooksey, commercialisation of the new cell designs could be just a few years away.

"We are optimising the design based on the models to maintain the superior performance of the cells throughout their lifetime," he says. "A normal aluminium electrolytic cell lasts for about six years before the refractory materials are degraded to such an extent that you have to rebuild it. And that's where the materials characterisation work comes in – trying to understand what's actually causing the advanced materials to degrade and ultimately fail."

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Research into computational fluid dynamics and physical modelling is under way to better understand metal, electrolyte and gas bubble movement in the cell

Modelling the future

In the mining industry, where massive machines are needed to process huge quantities of ore, the dollars needed for ongoing research and development are also enormous.

It used to be that to test out new equipment and processes, a mining company had to invest heavily in physical infrastructure to see if something would work in production.

But advanced computer software is changing all that, with mining companies increasingly using on-line models to test different processing techniques.

Rather than having to physically build and test the equipment used in the industries, a computer model can effectively achieve the same outcome, testing and refining processes until optimum performance is identified.

In particular, scientists are using models to study the flow of fluids used in a wide range of minerals processes. Known as computational fluid dynamics (CFD), researchers are using computers to simulate variations in the physical design and operational parameters of different processes, from those used in aluminium production to pig iron, nickel smelting, gold and zinc production.

Light Metals Flagship project leader Mark Cooksey says understanding how fluids behave during minerals processing is very important for improving the efficiency of processes.

For example, if a company wanted to test out a new type of stirring blade within a processing tank, the cost of making, installing and testing the new equipment would be expensive and often prohibitive.

"Instead, what you can do with CFD is build a computer model to predict what the different designs will do," Mr Cooksey says. "So it's a way of cost-effectively improving minerals processes."

In recognition of the growing importance of CFD, Australia will be hosting the Fifth International Conference on the Application of CFD in the Process Industries in Melbourne from 13 to 15 December 2006.

The conference will focus on the use of CFD in minerals processing, metal production, power generation, chemicals, food, oil and gas and other industries.

– TONY KAYE

For more information, visit www.cfd.com.au

SYNCHROTRON

Alternatives to traditional cement

By GIO BRAIDOTTI

SYNCHROTRON-BASED analytical methods are helping materials scientists use an energy by-product as the input for cement making, through a new process that lowers energy use and carbon dioxide emissions.

Cement may be a mainstay of the construction industry but synthesising it incurs high energy and environmental costs, primarily in the form of carbon dioxide emissions. The frequently quoted figure is a staggering one: making one tonne of cement releases one tonne of the greenhouse gas carbon dioxide.

Dr Matthew Rowles, a postdoctoral fellow with CSIRO Minerals, says cement is made by heating calcium carbonate to form calcium oxide. "About half of the carbon dioxide is released from the chemical decomposition," he says. "The other half is attributed to providing energy to heat up the cement kiln."

Substantial reductions on both the energy expenditure and the emissions are possible, Dr Rowles says, by replacing calcium oxide with fly ash – a by-product of burning coal – which is otherwise dumped in landfills. This alternative cement-making process requires first crushing the fly ash and then mixing it with sodium hydroxide to set the material as a 'geopolymer cement'.

Although that may sound simple in principle, analysing the resultant cement – to determine strength and durability – has required Dr Rowles to extend the capabilities of X-ray diffraction analysis as part of his PhD project, supervised by Professor Brian O'Connor of the Centre for Materials Research at Curtin University.

"Normal materials are crystalline and you can analyse them in the lab with traditional X-ray diffraction analysis, which examines the long-range structure and assumes that atoms are ordered over hundreds of bond-lengths," Dr Rowles says. "But geopolymer cement is amorphous; the atoms are arranged irregularly, so instead of getting sharp peaks in a diffraction pattern, the peaks are broadened into diffuse bumps making the pattern hard to interpret."

The problem is that laboratory X-ray sources are not very intense and the energy is not high enough to analyse amorphous materials such as geopolymers. But by using a synchrotron, Dr Rowles was able to get an X-ray source of much higher intensity and energy.

"It is helpful when designing new materials," he says. "With the amorphous technique, you can actually model the structure of the gel and see how the atoms are changing from the gel through to when they are semi-crystalline and crystalline – you can understand how the atoms are moving."

Using synchrotron facilities on two continents, Dr Rowles was able to establish that you can make geopolymer cement as strong as the regular variety. The new analytical methods may also allow for the development of designer materials and niche applications.

However, the benefits alone may not ensure industry uptake of the new technology. The energy savings and environmental benefits are real but, as Dr Rowles points out, there are costs associated with changing processing, transport and chemical handling procedures. "Industry may need a little push or some incentives because of these kinds of cost-benefit issues."

In the meantime, Dr Rowles is applying his synchrotron-based analytical methods to mineral processing. "I'm looking at bauxite and simulating in the lab how it is processed by industry. The synchrotron allows you to use sample cells and look at things while they are happening.

"You can watch the minerals dissolve and analyse the changes in states and determine the impact of changing conditions like temperature and pressure.

"With the Australian Synchrotron opening early next year, I'm looking forward to conducting such experiments virtually next door."

FOTOROM

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Parker Centre

The Parker Centre is a Cooperative Research Centre comprising four Core Research Participants (CSIRO Minerals, Curtin University of Technology, Murdoch University and the University of Queensland), nine Core Industry Participants from the minerals industry, and 12 Supporting Participants.
www.parkercentre.com.au

Directness: a key element of efficiency

Russell Pennifold and Dr Chu Yong Cheng conducting semi-continuous solvent extraction test work. PHOTO: JAMES ROGERS

By WHITNEY MACDONALD

INNOVATIVE solvent extraction technology that simplifies how nickel and cobalt are purified from ore could create direct economic and environmental advantages for Australia's hydrometallurgy industry.

After more than six years of research, a Parker Centre team has developed a number of synergistic solvent extraction systems that use more than one commercially available reagent to achieve greater selectivity and a more efficient metal recovery process.

Compared to current methods, the team's direct solvent extraction (DSX) technology can better meet industry's need for a selective extraction process. This has been verified through the completion of a phase 2 pilot-plant program conducted by Baja Mining Corporation at SGS Lakefield Research in Canada, processing ores from its Boleo site in Baja California Sur, Mexico.

Project leader Dr Chu Yong Cheng says that, unlike traditional processes used by large plants to extract cobalt and nickel from ore, the DSX technique avoids the intermediate precipitation step.

"Using our unique synergistic combination of reagents allows for greater selectivity and direct separation, and thereby avoids the complicated and somewhat hazardous precipitation and releaching steps," Dr Cheng says.

In developing the DSX technology, the researchers aimed to address some of the other shortcomings of available technology, including the considerable operating and safety difficulties, and environmental considerations such as energy consumption.

The Parker Centre worked with Baja Mining Corporation to optimise the patented DSX technology, tailoring it to the company's specific needs. Before the DSX technology, there was no SX method for selectively extracting cobalt from manganese, calcium and magnesium.

Dr David Dreisinger, who works with the Vancouver-based Baja Mining Corporation, says results from the six-week pilot study were excellent.

"The pilot plant was a big success with excellent manganese rejection. We achieved more than 99 per cent cobalt and zinc recovery from our feed solution while rejecting nearly 100 per cent of the manganese."

Following the success of the pilot plant, Baja Mining Corporation is looking to develop a full-scale plant using the DSX technology.

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Tailoring a golden solution

A recently commissioned cyanide leach circuit is helping Newcrest Mining Ltd increase gold recovery at its Telfer operation in Western Australia.

While most of the gold and copper at Telfer is recovered by flotation, some gold still escapes to the float tails. The Telfer circuit is able to capture some of this lost gold with a pyrite float and cyanide leach of the concentrate. Commissioning trials on the pyrite leach circuit in December 2005 highlighted problems involving reagent control.

Simon Hille, ore processing manager at Telfer, explains: "Copper and sulfide ions were interfering with our cyanide readings and we couldn't get reliable measurements."

Sulfide and copper levels are critical, as sulfide ions dramatically reduce the gold leach rate, while copper acts to exaggerate cyanide readings, causing operators to add less cyanide than is necessary for optimum gold recovery.

"So we engaged the Parker Centre to establish some protocols for accurately measuring cyanide in our complex solutions," Mr Hille says.

Working with Newcrest, the Parker Centre – through CSIRO Minerals – developed and tested a tailored analytical method for simultaneously measuring cyanide, copper and sulfide ions.

When the company started using the circuit in August, the new method successfully avoided the interference problems arising from standard techniques.

"We found this invaluable in setting our cyanide and oxygen addition rates within the circuit," Mr Hille says. "This in turn helps us increase gold recovery and meet our cyanide discharge requirements."

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FINE GRINDING

Fine-tuning fine grinding

By REBECCA THYER

AS the mineral liberation size of run of mine ores has significantly reduced over recent years, the challenge of developing energy efficient technologies to process them has risen remarkably.

About 70 per cent of a mineral processing plant's operating costs are in comminution energy to liberate mineral particles – a cost that increases exponentially as product size decreases.

Since the 1970s the standard feed size for mineral beneficiation has dropped from 74 microns, to 38 microns in the 1980s, to less than eight microns in the 1990s in a number of major mining operations in Australia.

These deposits require fine and ultra-fine grinding to be economically viable, and stirred milling is emerging as the answer.

It is an area that CSIRO Minerals Dr Mingwei Gao is working on.

Senior principal research scientist Dr Gao says traditional ball mills' large grinding media consume huge amounts of energy for fine grinding and the slow rotation mill speed results in a low power intensity.

"Low power intensity in a ball mill cannot deliver the high mill throughput required," he says. "And the impact and abrasive stresses used in ball mills do not work well for particle breakage when mineral particles are in the micron range."

Instead vertical and horizontal stirred mills use small media and operate with a set of stirrers rotating at high speeds. They rely on high-intensity agitation action to energise small grinding media and generate compressional and torsional forces that are very efficient for breaking micron-sized particles.

"However, further development of stirred mills is critical to their broader application and this is where CSIRO is assisting the minerals industry," Dr Gao says. "One of the challenges is to halve the energy consumption of modern stirred mills to economically produce products below five microns, because this will almost certainly be required by the minerals industry in the near future."

CSIRO is working on this and other developments, including 'coarse grinding applications' where the objective is to use stirred mills instead of secondary and regrind ball mills to avoid over grinding heavier minerals in the mill feed and to take advantage of the stirred mill's higher energy efficiency compared to ball mills.

CSIRO is also investigating dry processes for fine grinding, which, if successfully developed, will significantly reduce energy consumption and the cost for subsequent beneficiation processes.

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Working for the future

OPEN SPACE
DR PETER LILLY
CHIEF,
CSIRO EXPLORATION
& MINING

THE goal of reducing the energy consumed in processing is important to ensuring our industry has a future. It will reduce costs and lower greenhouse emissions, helping to sustain the industry financially, socially, environmentally and from a good governance perspective.

As the relatively new chief of CSIRO Exploration and Mining, my long-term goal is also a robust and vibrant minerals industry, and energy use is crucial to that. However, we face worrying trends.

Until now, skilled professionals have been available on demand, even if they have had to be imported, as I was in 1980. But we are on the edge of a significant demographic precipice and over the next 10 to 20 years, skills shortages in most key professions and trades will become chronic. Without R&D into new technologies that might otherwise alleviate some of these skills shortages, the minerals industry will race down a slippery slide to relative obscurity.

My other concern is the relative decline in exploration expenditure in Australia. The majority of Australian mines are based on discoveries that are more than 20 years old. Without new discoveries to replenish Australia's reserves, the wealth generated by mining and processing will be lost to future generations.

If we look at the distribution of exploration and/or mining company market value on the ASX, we find a significant gap in the middle ranks. Yet exploration in Australia is strongly dependent on the growth of a new cohort of mid-range companies with an Australian rather than a global priority to explore for, find, develop and release the wealth from new ore deposits.

There is no single answer to these complex problems. But science and technology will be at the heart of the solutions to all of them. The CSIRO Exploration and Mining response is to become involved – with industry, with technology transfer and with collaborators where there is a strategic need for work to be done.

CSIRO Exploration & Mining's HyLogging system can have as much impact on mineral processing as on exploration and mine development.
PHOTO: NORTH SULLIVAN

Partnerships: the way forward

LEADER'S FORUM
DR ROB LA NAUZE
PRINCIPAL, TECHNICAL STRATEGY ADVISORS
CHAIRMAN, AMIRA INTERNATIONAL

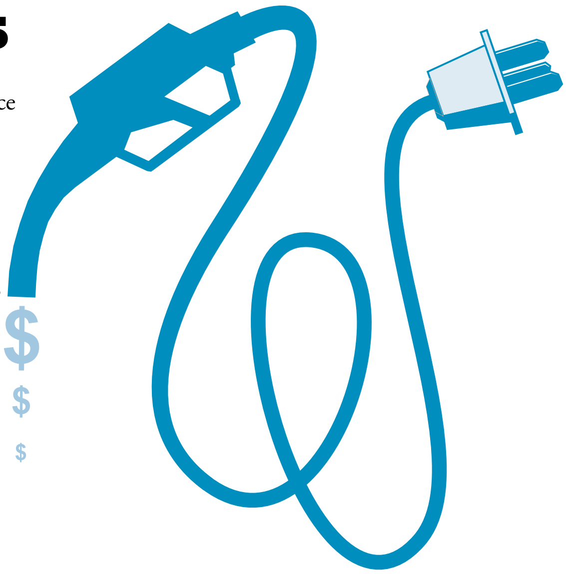
THERE is a change coming; I can feel it. The minerals industry is realising that improved performance through mergers, acquisitions, structural rationalisation and downsizing have run their course and future efficiencies will need to come from technological improvements. The recent significant financial commitment by a number of the more savvy companies in new and fundamental science and engineering embodied in the formation of the Australian Minerals Science Research Institute (AMSRI) is just one sign of this change.

But, while this is a positive sign, it will not be enough to sustain industry profitability into the future. Bold moves, such as the AMSRI initiative, need to be backed by much greater strategic partnership building by companies with Australia's world-leading research centres. For a start, companies themselves just do not have all the skills necessary.

A basic difficulty is who will pay to take such fundamental outcomes through the rigorous process from the bench to the demonstration plant. Some call this the 'valley of death': the chasm between low-cost research and high-cost development. In my own experience a major – perhaps the major – factor in successfully bridging this gap is the formation of sustained partnerships between the researchers and the developers; to the extent that during projects, the research institution becomes a true extension of the company, sharing its ambitions and strategic thinking.

A decade of poor returns has meant that the industry has had a very short-term focus. The recent better times will enable new strategic initiatives. Now is the time for companies and researchers to build the substantial and enduring partnerships that will ensure the next productivity leap. I can feel the change coming.

Death, taxes and oil prices



By MICHAEL WEIR
Senior Resources Writer,
The West Australian

EVERYONE knows that death and taxes are two certainties in life. But another thing that is quickly becoming a certainty is that oil prices are not going to substantially go down any time soon.

With developing countries like China and India growing at a seemingly unstoppable pace and the never-ending energy hunger of the US, the cost of energy is rocketing.

Never has there been a better time for the Australian mining industry to focus on ways to reduce energy needs.

And with energy being one of the biggest input costs in any operation, any reduction in that cost is pure bottom line: a great incentive.

With commodity prices soaring and profits strong the industry is in great shape, which means companies should be in a good position to divert some money into research and development in the area of energy reduction.

And putting best practices in place now will also stand the industry in good stead when the next downturn comes.

Although there are obvious cost benefits in reducing energy needs, we also should not forget the environmental benefits, which brings me to an interesting point.

The Woodside Petroleum-managed North-West Shelf liquefied natural gas (LNG) project, Australia's biggest resource project, often comes in for criticism because it is also one of the country's single largest greenhouse gas producers.

It takes an enormous amount of energy to super-cool natural gas so it becomes a liquid and is safe to transport, which in turn produces enormous amounts of greenhouse gases.

But what is often forgotten is that the LNG produced in Australia is used as fuel in countries where the only alternative energy source would be dirty, poor-quality coal burnt in old, inefficient generators – producing far more greenhouse gases than the combined processing and burning of LNG. So the net benefit to the global environment is a plus.

However, it is not only on the processing side where energy savings can be made in the resources sector.

With heavy mining equipment burning through hundreds of litres of diesel a day, any way of reducing their use or energy demands would be a benefit.

One bloke who is passionate about this issue is former miner Mick Roberts. For some years now he has been pushing the idea of using an electric monorail system to replace the use of heavy haulage equipment.

The Kalgoorlie School of Mines consultant, together with senior lecturer Emmanuel Chanda, has written a paper on the subject espousing the benefits, which include doing away with diesel-powered trucks, boggers and personnel carriers and being able to dig mining tunnels that are narrower and steeper.

Mr Roberts says electric monorail haulage technology has been used in hard-rock mines in South Africa for many years and that industry has started to see the benefits.

Further work is needed, but he says an electric monorail could be more cost-effective than conventional methods because the same system could be used to transport workers, materials and ore. Furthermore, mining tunnels could be smaller and steeper, adding to the cost savings, while there are also obvious benefits of an electricity-based system against the backdrop of volatile diesel prices and environmental concerns.