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CSIRO research in minerals processing and metal production

FEBRUARY 2005

PROCESS

WASTE RECOVERY

Rescue mission



SALVAGING SOMETHING FROM THE WRECKAGE: CSIRO MINERALS IS INVESTIGATING WAYS TO REDUCE SLUDGE VOLUMES.

IMAGE © JOHN FAIRFAX PUBLICATIONS PTY LTD

By GRAEME O'NEILL

IN THE age of environmental responsibility, old cars no longer rust away disgracefully, overgrown by weeds in remote country paddocks.

Today they disappear into the jaws of huge shredding machines in metal recycling plants in Australia's capital cities, along with expired washing machines, refrigerators and light metal wastes.

Powerful electromagnets draw out the larger steel fragments for re-melting in electric arc furnaces, while further separation steps remove larger fragments of non-ferromagnetic metals like brass and aluminium.

The separation processes result in large volumes of intractable sludge containing about 25 per cent water, as well as small particles of steel, copper wire, brass, solder (a lead-tin alloy) and aluminium, mixed with vinyl and other plastics, synthetic fibres, fabric,

Key points

- Rising disposal costs are forcing industry to address disposal options.
- Waste sludge contains recoverable copper and clean steel – materials that are of value in some metal-recycling plants.

rubber, glass, quartz and wood.

CSIRO Minerals Project Leader Warren Bruckard has been investigating new ways to reduce sludge volumes and to increase the recovery of metals and other recyclable materials – something in which steel producer Smorgon Steel Recycling is interested.

Smorgon Steel Recycling Victorian General Manager Mr Peter Morrison says his company is committed to reducing waste volumes sent to landfill and is considering processes developed by CSIRO Minerals.

Typically, metal recyclers disposed

of shredder sludge in landfill or toxic-waste dumps. But rising disposal costs, tightening government regulations and social concerns are forcing industry to address disposal options and consider methods to get more from their waste. As recent experience in Victoria attests, local communities strongly oppose any attempt to locate new toxic-waste dumps in their urban or rural municipalities.

Current techniques used by metal recyclers are not efficient in disaggregating the complex mix of materials in shredder sludge to recover recyclable materials, so Mr Bruckard turned to separation methods used in the minerals industry for potential solutions.

His research team initially applied sophisticated physical and chemical analysis techniques, to characterise in detail the sludge from Smorgon Steel Recycling's plant. The preliminary characterisation step is

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COMMENT DR BART FOLLINK

CHIEF, CSIRO MINERALS



Striking a balance

Over the years, CSIRO Minerals has established its reputation as a technology partner of choice for the minerals industry.

In close collaboration with our industrial partners and other parties we have achieved higher-efficiency processes and equipment, and designed entirely novel and visionary technologies.

These achievements are based on a keen willingness to partner and a deep knowledge of the needs of the minerals industry, and are underpinned by our strong scientific capabilities.

The minerals value chain has long been of great importance to the wellbeing of our nation. In a society where priorities and values are constantly evolving, minimising the environmental impact of these activities has now become a recognised key priority.

The scientific capabilities and technological skills that we develop and maintain within our division, in combination with our team's understanding of the industry from mine to metal and beyond, enable us to actively contribute to the protection of our unique Australian environment.

We keep targeting our science, capabilities and skills at increasing the nation's wealth from mineral resources, but with an ever-increasing attention to our natural surroundings. Our current portfolio of activities ranges from work on zero-waste processing and targeted exploitation of lower-grade deposits, to extraction of value from by-products.

We will continue to hone our scientific and technological skills, using all our creativity to generate innovative ideas to maintain competitiveness and social acceptability for the Australian minerals industry.

We hope the current issue of Process gives you a flavour of what CSIRO can contribute to the development of environmentally responsible mineral processing.

Rescue mission FROM PAGE 1

critical not only for process development but also for the recyclers themselves – they need a clear understanding of the chemical and physical nature of the wastes they are producing and treating, if they are to comply with disposal regulations and reporting requirements.

The analysis showed the sludge contained about 3.1 kilograms of recoverable copper per tonne of dry feed and about 33kg per tonne of clean steel.

As these materials are of value, some metal-recycling plants could recover the cost of installing and operating an additional plant required to process shredder sludge.

However, comparatively speaking the recovered materials are relatively low in value. Therefore Mr Bruckard believes the most basic requirement is that any recovery process must not only be relatively simple, but also cheap to run.

The CSIRO team has proposed a process that would combine hydraulic classification to remove plastic, foam, rubber and other low-density, non-metallic materials, magnetic separation to concentrate clean steel, and gravity concentration in a jig to separate low-density materials like calcite and glass from the high-density metals like copper, lead and brass.

The process would be refined to optimise the grade and recovery of the valuable materials while making the residual waste stream more benign for disposal.

Mr Bruckard says further development work is now needed on a larger scale, and with a wider range of samples, to prove the economic benefits of the proposed treatment processes.

Mr Morrison says Smorgon is considering options, such as the CSIRO process, to treat shredder sludge and recover contained values.

He welcomes CSIRO's initiatives in the general waste treatment area and looks forward to working further with CSIRO on Smorgon Steel's waste streams.

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Any recovery process must not only be relatively simple, but also cheap to run

RESEARCH

Dry slag granulation turns waste into value

A NOVEL dry method for slag granulation could help the cement, iron and steel industries develop sustainable practices and derive value from waste.

About 300 kilograms of slag is generated for every tonne of iron produced. Slag wastes are usually air-cooled in large pits or water-granulated, and then sent to landfills or used in low-level applications such as road base materials.

Some blast furnace operations water-quench discharged slags to produce glassy granules, which can be used in cement.

"The new, dry way of treating slags offers a number of benefits over the traditional wet method," says CSIRO Minerals Project Leader Dongsheng Xie.

The process involves feeding molten slag on to a rotary disc. This disc spins at high speed, breaking the slag into small droplets and rapidly solidifying them to produce glassy granules with similar properties to those produced by wet granulation.

With these properties, the granules can be used in Portland cement, which is a key constituent of concrete – the most consumed mineral product on earth (at about 1.7 billion tonnes annually).

Producing one tonne of Portland cement consumes about 3000MJ of electrical and thermal energy and emits about 900kg of carbon dioxide, mainly due to the decomposition of limestone in the cement kiln.



CSIRO'S DRY GRANULATION PROCESS: MOLTEN SLAG POURS ON TO A ROTARY DISC.

PHOTO: STEVE SANETSIS

Granulated slag can substitute for up to 70 per cent of the Portland cement, leading to significant energy savings and reduction in greenhouse gas emissions.

"The wet granulation method involves high capital costs," says Dr Xie. "And it doesn't contribute to sustainable practices because it consumes excessive amounts of water, doesn't recover heat, and generates environmental problems such as acid mist.

"With a lower capital cost and benefits in heat recovery and reduced air pollution, dry granulation is an attractive alternative to conventional wet granulation."

The CSIRO team has built a pilot-scale facility and tested the dry method with several slags from

ferrous and non-ferrous industries.

"With a good understanding of how slag properties influence the granulation process, we can tailor-design processes for a variety of slag wastes," says Dr Xie.

"This process is likely to become part of our future work at the Centre for Sustainable Resource Processing [see page 6].

"We've had growing interest from several overseas and Australian companies and we'll work with them to turn the dream of zero-waste processing into a reality."

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Waste not, smelt lots

Forestry and mineral processing scientists are proposing an ambitious project to replace coal in metallurgical processes with char produced from a wide range of wastes.

With its high reactivity and low sulfur content, char from the pyrolysis of carbon-containing wastes – such as those from forestry practices, agriculture, sawmilling, paper, cardboard, biosolids and possibly old tyres – could be used in operations such as slag furning, bath smelting, synthetic rutile production and iron ore sintering.

Regional centres such as Port Pirie, Werrabee and Newcastle would be suitable locations for such an operation, as agricultural and forestry industries exist in these regions and local smelters could directly use the char.

"It's an attractive proposal for many reasons," points out CSIRO Minerals Project Scientist Michael Somerville, whose team has begun

discussions with the Port Pirie Regional Development Board.

"The main benefits are environmental, through re-using waste, and drastically shortening the carbon dioxide cycle, reducing net greenhouse gas emissions."

There are also processing benefits from using a more reactive reductant and economic benefits for both smelters and councils.

The proposal is based on a technique developed by CSIRO Forestry & Forest Products (CFFP), in which carbonaceous wastes are heated under a controlled atmosphere to produce char, gas, bio-oil and an aqueous phase.

"Similar pyrolysis operations form the basis of Brazil's iron and steel industry," explains CFFP's Project Leader Dr Paul Fung. "There the gas is burnt to further fuel pyrolysis and the bio-oil is used as fuel oil substitute for heating."

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CUSTOMERS

Zinc smelters may be fed with dust



CYCLONING: KEVIN DAVEY SEPARATES THE COMPONENTS OF ELECTRIC ARC FURNACE DUST.
PHOTO: CHRISTIAN PEARSON

By **REBECCA THYER**

A ZINC-RICH material made from an industry waste product has the potential to provide an additional revenue stream for one of Australia's largest steel producers.

Early testing work by CSIRO Minerals illustrates it is possible to produce an attractive feed material for zinc smelters from waste dust created during Smorgon Steel's steel-making process.

Smorgon Steel currently uses 100 per cent recycled ferrous scrap – mainly from discarded motor vehicles and offcuts from engineering workshops – as a feed material. After the scrap is sorted and processed it is melted in an electric arc furnace (EAF), which generates dust as a waste product.

As the scrap steel contains galvanised material, this dust contains a mix of iron, zinc and calcium oxides. However, its fine particle size makes handling and processing difficult. Many European and North American EAF steelmakers send this dust to landfill, but environmental and economic concerns have led Smorgon to re-evaluate its options.

Smorgon Technical Manager Dr Leo Frawley says: "The project with CSIRO has investigated processes to concentrate the zinc in the dust to make this an attractive feed material for zinc smelters and to reduce costs or provide a revenue stream for Smorgon Steel."

Smorgon currently pays zinc

reprocessors Hydromet in New South Wales and Zinfex in South Australia a gate fee to take the dust. However, by increasing the EAF dust's zinc content, this waste stream could become revenue generating.

CSIRO scientist Kevin Davey says that because EAF dust is seen as hazardous, disposal options are costly. It is mostly sent to specialised landfill sites, although some secondary zinc processors are paid to take it.

"Tipping costs are likely to increase, plus there are environmental concerns with landfill. Companies are interested in options that offset their disposal costs and reduce volumes sent to landfill."

Techniques employed in the US and Europe to recover zinc from EAF dust are not economically viable for Australian producers.

Mr Davey says: "Australia produces EAF dust on a much smaller scale than the US so there is a lower economic benefit and higher unit processing cost in using these techniques here. There is less commercial impetus for companies to use these techniques, as landfill costs are not prohibitive at present.

"Pyrometallurgical and hydrometallurgical processes are generally more complex and expensive than physical separation technologies, which is what we've been looking at," he says.

CSIRO Minerals was initially approached to undertake characterisation work on the EAF dust in order for Smorgon Steel to understand more clearly its nature. X-ray diffraction and scanning electron microscopy techniques identified the mineral phases present, their relative abundance, the zinc associations and elemental distribution by size. "Having done that we undertook some tests using simple laboratory-scale mineral processing techniques," Mr Davey says.

The first technique – cycloning (or elutriation) – separates the components in the dust on the basis of particle size.

"We found that a lot of the zinc was contained in the fine sizes. Cycloning meant we could split the dust into fine and coarse components and achieve an upgrading in zinc. And being a wet process, we could also remove water-soluble components such as chlorine and fluorine, which are penalty elements for secondary processors," he adds.

CSIRO Minerals' tests using another technique – wet magnetic separation – demonstrated similar results.

"The coarser material was more magnetic, allowing us to separate the dust into magnetic and non-magnetic components, again achieving an upgrading in zinc," Mr Davey says.

Both processes showed more than 90 per cent of zinc could be recovered from the EAF dust, upgrading the zinc content, while effectively reducing the levels of penalty elements. Mr Davey says the rationale behind using these techniques is simple. "We wanted to come up with a process that would be simple and less costly than other processing techniques and would make the dust more attractive to a secondary processor, thus reducing dust disposal costs.

"We've demonstrated the success of the technique in the lab and the next step is to demonstrate the process on a larger scale."

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WASTE MINIMISATION

Recovering lead from battery slag

By REBECCA THYER

REDUCING waste sent to landfill not only makes environmental sense but also economic sense, as rising disposal costs make waste minimisation an economic imperative for many companies.

Offsetting waste disposal costs was key in developing methods to recover lead from a waste slag, according to CSIRO Minerals Project Leader Warren Bruckard. However, the possibility of an additional revenue stream – lead can sell for up to \$400 per tonne – was an added incentive. His team has been working with a small, secondary lead smelter that collects and recycles spent lead-acid (car) batteries to characterise its waste lead slag and develop methods to recover residual lead from it. The company's current process creates about 6000 tonnes of lead slag annually.

"It recycles spent batteries by removing the plastic casing and smelting the contents to recover lead metal. However, the smelting process also produces a waste slag product," Mr Bruckard says.

"Slag produced from lead-acid battery smelting contains five to 10 per cent residual lead and because of its heavy metal content, this slag has to be disposed of in costly, specialised landfill sites."

The focus of this work was to develop a cheap, simple process that could easily add on to existing smelting processes to allow the recovery of the lead contained in the slag. The slag composition is complex. Lead can occur in five different forms so it was important to first characterise the slag.

The recovery strategy that followed was two-fold and involved recovering the coarse and fine lead separately.

The coarse lead was recovered in a grinding and screening process. Lead's malleability means it forms large flattened plates or discs when ground, making its subsequent removal by screening quite simple. Fine lead was recovered using a flotation process, an area in which CSIRO has a strong background and expertise.

Mr Bruckard says: "We are hoping that when our work is completed, the



WARREN BRUCKARD TREATS BATTERY SLAG IN THE LAB-SCALE FLOTATION CELL. PHOTO: CHRISTIAN PEARSON

More businesses will have to find viable alternatives

process will be economically viable and applicable to other secondary smelters, including those overseas."

Disposal costs may be creating economic pressures, but social and political pressures are also making companies rethink disposal options. "It's been relatively easy to send waste to landfill in the past, but the government and social groups have been putting heat on businesses to reduce reliance on landfill," Mr Bruckard adds. "If tipping fees rise significantly, more business will have to find viable alternatives to dumping waste – CSIRO Minerals can help find solutions."

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Samples

Process opens doors for auto industry

Breakthrough technology for casting magnesium, T-Mag, will help promote the use of magnesium in the automotive, telecommunications and aerospace industries.



Light Metals Flagship researcher Dr Thang Nguyen says key benefits for industry from this high-yield, high-integrity process include greater flexibility in design and the ability to cast complex shapes.

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New Chief Scientist for Minerals

CSIRO Minerals has appointed John Rankin to the new position of Chief Scientist – a role that involves matching science 'push' with industry 'pull'.

"We rely heavily on industry pull to identify the challenges we can help overcome," says Dr Rankin. "Providing solutions to these challenges draws on a wide range of sciences, and it's advances in these science areas that enable us to develop the new tools and capabilities we need to meet industry needs."

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Field trials for evaluation process

The Worldwide Fund for Nature (WWF) has begun field trials in Brazil and Australia to test the Mining Certification and Evaluation Project process.

The project aims to evaluate whether independent third-party certification of social and environmental performance can be applied to the mining industry to recognise good practice and provide a means for companies to assess current performance at the mine site.

CSIRO staff and people from a diverse range of sectors – including mining, accounting, labour, government and non-government – have worked collaboratively to establish the evaluation criteria.

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SUSTAINABLE PROCESSING

A visionary mission: towards zero waste

By **BRENDA LEAHY**

AS THE old adage goes, you cannot make a silk purse out of a sow's ear.

But pioneering work at the Cooperative Research Centre for Sustainable Resource Processing (CSRP) is proving otherwise, with the development of technical solutions that promise to transform waste from mineral processing and metal production industries into valuable resources.

Iron and steel from smelted red mud (bauxite residue), hematite 'iron ore' from copper-uranium tailings and a biomass-derived charcoal fuel from a salinity solution that may close the carbon loop while reducing coal consumption – these are among some of the breakthrough initiatives and visionary assignments emerging from the CSRP as it explores a new and sustainable way forward for industry under the heading of "Towards Zero Waste and Net Emissions".

Launched in October 2003, the Centre's overall mission is to reduce the ecological impact of resource processing and progressively eliminate waste and emissions, in ways that enhance business performance and are in line with community expectations. So far it has launched a series of innovative projects, each with separate expected outcomes, but connected to the major foundation Towards Zero Waste project.

Essentially, the work examines resources going in and coming out of the mineral processing cycle. On the input side, advanced mineral processing and metal extraction techniques are being applied to help industry efficiently use mineral resources and reduce wastes in materials cycles. At the other end, notorious mineral processing by-products – residue, sludge, slag, fumes and dust – are being put under the microscope to identify and test the potential for the separation, recovery and reuse of valuables.

CSRP Program Leader Dr Sharif Jahanshahi says Towards Zero Waste

is the defining project, which informs and guides the role, scope and extent of the current and future projects in the CSRP's expanding portfolio.

Towards Zero Waste researchers and their strategic partners have looked at a large number of waste streams, developing a systematic approach for characterising and prioritising the top 20 industrial wastes for future investigations, reviewing literature and industry practices and developing conceptual flowsheets with zero-waste outcomes.

"In order to rank and prioritise the top 20, we applied a decision support framework, purpose-designed by our partners at the University of Sydney," says Dr Jahanshahi. "Further, we adopted a consultative, cross-discipline and multi-functional approach involving industry, researchers and agencies such as the EPA."

In the ranking process, a range of factors came into play, including the techno-economic and socio-political dimensions, as well as issues and

challenges specific to each waste.

Among its top priorities, Towards Zero Waste identified the opportunity to address red mud from bauxite processing in the aluminum cycle.

Australia currently produces about 30 million tonnes per annum, and it is estimated that about 80 million tonnes per annum are produced worldwide, a factor influencing its number one ranking in the Towards Zero Waste project.

At a discrete project level, breakthrough technologies to extract valuable resources from red mud are being developed by the research team, with a range of viable options now on the horizon. These include smelting red mud for pig iron, a recycled soda- and alumina- rich stream for alumina production and a slag containing titanium, silica, lime, alumina and magnesium. Simple separation techniques are being applied to the slag to separate a high-grade titania product and a residue suitable as feedstock for a cement

Zero Waste Priorities

AT A GLANCE

Project: Recovery of valuables from red mud.

Focus: Technically and economically viable processing options for recovering valuables from red mud in a sustained way.

Scope: Literature reviews to avoid duplicating previous studies and strategies and ensure relevance and currency, especially key issues confronting the industry, such as red mud disposal. Characterisation studies to pinpoint physical properties of red mud, including chemical and mineralogical analysis and radioactivity department. Laboratory smelting trials on red mud samples aimed at producing a range of value-added products in a zero-waste mode.

Outcomes: Identified the key properties of red mud for future processing and to assess the potential for fractionating valuable constituents into various sizes to enable their separation. Potential to smelt red mud to produce a pig iron product, a soda-rich fume and a slag containing titanium, lime, alumina, silica and magnesium. Application of separation techniques to the slag to beneficiate a high-grade titania product and a residue suitable for cement kiln.

Status: Industry support being sought to continue studies and opportunities to test processing options on more red mud samples.

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waste

kiln. The net effect, according to the researchers, is that valuables in the mud are deported to saleable product streams in which there is no final waste.

THE VALUE IN RED MUD: MANDIE MATHESON PERFORMS A LOW-TEMPERATURE WATER LEACH ON A SAMPLE.
PHOTO: CHRISTIAN PEARSON



'In many ways, it's a transformational approach to our own work'

Among the other high priorities is a project targeting copper removal from tailings by chloride volatilisation to produce a valuable new iron resource. "This promising project, while still in its early stages, is currently being exposed to industry for comment and we can see a clear path forward," says Dr Jahanshahi.

In another project, the researchers from CSRP, the Salinity Cooperative Research Centre and the West Australian Department of Conservation and Land Management are working on biomass-derived fuels and reductants for high-temperature metallurgical processes,

including rotary kilns and bath smelters.

This R&D team is zoning in on the potential to use woody residues – from short harvest cycle trees (oil mallee) – for generating low-cost charcoals as a sustainable alternative to greenhouse gas producing coal. Notably, the woody residues are from trees being planted in West Australia's wheat belt as part of a salinity treatment program which involves lowering the water table.

"The early indicators from this research are that due to the high reactivity of charcoal, we may be able to replace one tonne of coal with far less charcoal. And there are other benefits: it helps close the carbon loop and reduces dependency on fossil fuels," says Dr Jahanshahi.

He says the success of Towards Zero Waste and the allied projects hinges on its multi-disciplinary approach. It brings together the stakeholders, as well as the scientific and engineering experts, during each phase of research, development, pilots and feasibility studies to examine the full spectrum of issues and opportunities.

"The zero-waste concept and full-value recovery requires chemical and phase transformation. Our expertise in high-temperature processing plays a central role in unlocking elements from crystalline lattices, as well as enabling them to be separated into different product streams.

"We are working across technical boundaries, both scientific and in engineering, and with all key stakeholders. Together we can think critically, differently and strategically about the business case and viable solutions that will take the industry forward to its preferred future. In many ways it's a transformational approach to our own work," he says.

The Centre has national and global capability, with nodes in Perth (its head office), Melbourne, Sydney and Brisbane, and key research partners including CSIRO, Curtin, Queensland and Sydney universities and ANSTO.

Alcoa, Rio Tinto and WMC have been in there from the start, initially providing seed funding and direction towards the research portfolio.

According to the Managing Director of Alcoa World Alumina Australia, Wayne Osborn, the CSRP's work underlines Alcoa's own focus on improving the manufacturing process, and in turn, improving the 'whole of life-cycle' value of aluminium.

RECYCLING WASTE

Stripping ammonia bare

STEAM and the right conditions can efficiently remove ammonia from magnesium production's intermediate chemicals in a continuous process, increasing metal recovery and reducing reagent use and expensive waste treatment.

CSIRO Minerals and AMC have developed a technique to eliminate ammonia from magnesium chloride ammoniates – intermediates made in the production of magnesium metal using the AM Process – and thus recover value from what would otherwise be wasted.

“Magnesium chloride ammoniates are not something you want to put down the drain,” explains CSIRO Minerals Project Scientist David McCallum. “Besides, they still contain precious feedstock for the production of magnesium metal. To treat the solid ammoniates, we first make a concentrated solution by slurrying it up in water.”

The slurry is fed down through a special ‘bubble-cap’ column into the base of which steam is bubbled. In a process called stripping, the steam rising up through the column vaporises some of the volatile ammonia at each stage.

“Our pilot-plant column has 20 stages, but we found the AMC slurry needed far fewer to lower the free ammonia in solution to a level allowing return of the solution to the process – equating to about one hour's residence time,” says Mr McCallum.

The collected gas is cooled in a sequence of chillers and condensed down to aqueous ammonia, which can then also be fed back into the AM Process.

“So not only are we avoiding expensive treatments such as biological nutrient

removal, but we're managing to recycle all the component chemicals and therefore cut down on reagent consumption and process costs,” says Mr McCallum. “We've used this technique before on other waste streams, stripping phenols and other volatiles from solution.

“We did a few trials on the AMC ammoniates to determine the optimal slurry-agitation time, steam conditions and gas-to-liquid ratio.”

This ratio is particularly important, as too little steam would not strip the ammonia effectively. Too much steam unnecessarily dilutes the products, requiring additional energy to remove the water.

“We're very happy with the process we've devised with AMC,” says Mr McCallum. “It can be confidently applied to the design of a large, plant-scale column.”

AMC General Manager of Magnesium Production, Dr Greg Sheehan, says: “CSIRO provided a fast, efficient service utilising an excellent test facility and highly capable staff.

“The CSIRO team worked very cooperatively with AMC's process design engineers to provide a robust and cost-effective solution to a difficult issue.”

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BUBBLE-CAP: DAVID MCCALLUM OPERATES CSIRO'S 20-STAGE COLUMN.
PHOTO: CHRISTIAN PEARSON

LIGHT METALS

New process for cheaper titanium alloys

By KATE MILKINS

□ A new process for producing titanium alloys will provide greater opportunities for developing ultra-lightweight components in the automotive and aerospace industries.

The process being researched by the Light Metals Flagship allows the direct production of titanium aluminides and conventional titanium-aluminium alloys in fine powder form, at a much lower cost than existing technologies.

“Preliminary estimates show a five-fold cost reduction, which should open the way for many new applications,” says Jawad Haidar of CSIRO Industrial Physics.

Titanium aluminides possess attractive qualities for the aerospace and automotive industries due to their low density, high strength, corrosion resistance and ability to withstand temperatures up to 900°C in air. However, current methods are expensive as they require titanium and other alloys to be melted prior to producing metal powder.

“The new method, which involves reduction of titanium chemicals using aluminium, is expected to be much cheaper than existing processes as it allows production of high-quality powder directly from raw materials,” says Dr Haidar.

The Flagship team has successfully produced a series of titanium-aluminium-based alloys (with alloying additives such as chromium and niobium), other titanium aluminides, and titanium-aluminium-vanadium alloys. The process is capable of producing high-quality, fine powders with particle sizes down to less than 10 microns.

“Our progress to the proof-of-concept stage and our ability to produce a whole series of alloys is exciting and opens doors to a much broader range of applications,” says Dr Haidar. “We are now very keen to work with a partner to develop a pilot plant.”

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SYNCHROTRON

New synchrotron will boost capability

By CAROLINE GILL



AN ARTIST'S IMPRESSION OF THE AUSTRALIAN SYNCHROTRON, DUE FOR COMPLETION IN 2007.

IMAGE: DEPARTMENT OF INNOVATION, INDUSTRY AND REGIONAL DEVELOPMENT, GOVERNMENT OF VICTORIA

WHEN Ian Madsen and his CSIRO Minerals research team in Melbourne wanted to use a synchrotron to do in-situ experiments on mineral processing reactions, they had to cart almost 30 kilograms of equipment to Britain.

It was a costly, time-consuming exercise but necessary because Australia does not have the highly specialised, rare technology. Demand for the synchrotron instruments is so high among scientists world-wide that the CSIRO team applied to use it in November 2003 but only gained access to it in September 2004.

"It was a huge logistical problem to get time on the instrument," says Mr Madsen, Science Adviser for Analytical Science at CSIRO Minerals. "We had to take everything associated with our sample environment, every tiny little nut and bolt that you can imagine, because if we didn't have it when we turned up it would have been impossible to replicate in the short time available to us before the start of our experiment."

Australian scientists will no longer need to undertake such expensive journeys when the nation's first synchrotron is built at Clayton in Melbourne in 2007, in a \$206 million project funded mainly by the Victorian government. Other partners include CSIRO, ANSTO, Monash University and Melbourne University.

Synchrotrons are highly sought after machines because they produce super bright X-rays with an intensity up to one billion times brighter than what can be achieved currently with conventional

laboratory sources. Overseas synchrotrons have been used in research dealing with bioremediation of mine sites, tailing dams and decontamination of soils containing toxic metals, such as arsenic and chromium. Some synchrotron instruments have the unique ability to simultaneously measure the mineralogical associations of a mineral sample along with the chemical state of constituent elements on areas as small as one micron in diameter.

It is expected to have enormous potential benefits for mining and mineral processing companies in Australia, once the research results from CSIRO and other organisations start to provide valuable information for mine operators and firms involved in cleaning-up former mines or toxic sites.

"Before you do a clean-up of a mine site you need to understand its mineralogy and the chemistry at a micro level, to ensure what you do is effective and safe to control the site at the macro level," says Mr Madsen. "CSIRO Minerals will be an important link between the minerals industry and these very high-level, analytical techniques available at the synchrotron."

Dr Lindsay Sly, Head of the University of Queensland's Department of Microbiology and Parasitology, is another scientist looking forward to a synchrotron being built on Australian soil. Part of Dr Sly's research involves using natural micro-organisms to make acidic discharge waters from mines safe to be released into the environment.

His experiments have focused on using natural bacteria to reduce sulfate to sulfide to react with toxic heavy metals to form insoluble metal sulfides, which do not leach into the environment. He believes a synchrotron would make it easier to study the metal sulfides being produced, to see how they relate to the composition of natural sulfides and how they interact with the micro-organisms producing them.

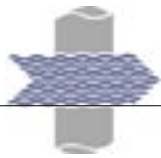
Dr Sly is also using bacteria to bioleach valuable minerals, such as chalcopyrite, to recover copper from minerals. The synchrotron could help his research team understand the relationship between the bacteria and the surface of the chalcopyrite where the bioleaching occurs.

"One of the biggest issues facing the mining industry is the closure of mines that have finished their active life," Dr Sly says. "Many governments and environmental protection agencies now require companies to have an on-going management program to ensure there's no long-term problem with the release of these compounds."

"We're looking for cheap and sustainable methods to treat these waste streams – methods that do not require massive input of sophisticated chemical processes and treatment plants that require a lot of highly trained staff to run them. We're looking at longer-term sustainable processes that can be operated in remote areas."

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Turning trash into treasure

HITEC Energy Ltd will produce high-value, high-quality electrolytic manganese dioxide from ore waste thanks to the Parker Centre's tailor-made solvent extraction technology.

"HiTec Energy has been developing novel process routes to treat low-grade and waste manganese sources for the alkaline battery market for several years," says Parker Centre Solvent Extraction Project Leader Chu Yong Cheng.

"With the establishment of its commercial production facility in Kalgoorlie next door to a nickel laterite producer, the company now has the opportunity to combine its existing leaching technologies with specialised processes and turn manganese-containing waste streams into a useful product."

HiTec Energy has collaborated with the Parker Centre for a number of years in areas involving electrolytic manganese dioxide (EMD) and battery-related technologies. It looked to the Centre's solvent extraction (SX) group

to identify a suitable organic system to concentrate manganese in a nickel laterite waste solution and separate it from calcium and magnesium.

"We have developed SX processes to separate manganese from nickel and cobalt and we applied this expertise to HiTec Energy's project," says Dr Cheng.

The Parker Centre SX team conducted batch tests with eight different organic systems and looked at selectivity and extraction and stripping kinetics.

"We narrowed it down to two systems for further testing," says Dr Cheng. "In the end, we found that the Versatic 10/synergist system would be better than a pure Versatic 10 system because the former lowered the risk of gypsum formation and required fewer SX stages, resulting in a reduced organic

inventory and lower capital costs, offsetting the higher reagent costs.

"Our results suggest the system could achieve a manganese extraction efficiency greater than 99 per cent in two stages of extraction," says Dr Cheng. "And the extraction and stripping kinetics were very fast."

By extracting manganese from waste streams to produce EMD, HiTec Energy is reducing the need for further manganese ore mining and associated land disturbance, the energy consumption and greenhouse gas emissions of EMD production, and is easing the waste treatment burden on mineral processing operations.

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HiTec Energy is reducing the need for further manganese ore mining

Working together to recycle metals from e-waste

By ROS DILWORTH

FIFTY industry, government and research representatives came together recently at a workshop in Perth to discuss the challenges involved in dealing with Australia's growing volumes of unwanted electronic products (e-waste) and spent batteries.

"Two Korea Institute of Geoscience and Mineral Resources (KIGAM) researchers, with expertise in recovering valuable metals from electronic scrap and batteries, introduced the audience to KIGAM recycling technologies," says workshop convenor and Parker Centre Deputy CEO Dr Jim Avraamides.

"These researchers are involved in a joint project in which the Centre's hydrometallurgy capabilities are complementing the current KIGAM research effort in this area."



DR JEONG-SOO SOHN (KIGAM), CONVENOR DR JIM AVRAAMIDES (PARKER CENTRE) AND DR JAE-CHUN LEE (KIGAM) AT THE METALS RECYCLING WORKSHOP.

PHOTO: KELLY DWYER

In 2003 the South Korean Government introduced an Extended Producer Responsibility Program, making computer and white-goods appliance producers legally responsible for recycling a specified proportion of their products.

At the workshop KIGAM's Dr Jae-Chun Lee outlined his organisation's work to assist manufacturers meet these targets, including the development of technology for reclaiming metals from computers and cellular phones which has led to a successful commercial plant. His colleague, Dr Jeong-Soo Sohn, described KIGAM's activities in developing processes for dry cell battery recycling.

Eight Australians – including industry suppliers, commercial recyclers and representatives from all tiers of

government – also presented.

Topics covered in the workshop included the e-waste policy and legislative issues facing Australian Federal and State Governments, collection considerations for local governments and recyclers, consumer attitudes, e-waste processing challenges, international efforts to tackle e-waste, methods for treating spent batteries and technologies for e-scrap recycling.

The workshop was made possible by an Australian Government grant awarded in 2004 to advance the collaborative relationship between the Parker Centre and KIGAM.

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RESEARCH

Recovering aluminium metal from dross

RESEARCHERS have developed methods to recover fine aluminium metal from complex aluminium drosses, increasing process yields and reducing the volume and toxicity of these waste products.

Aluminium drosses are formed during the smelting of alumina and the remelting of aluminium scrap. They contain up to 60 per cent aluminium in many forms, including free metal and aluminium oxides, nitride and carbide.

These drosses are toxic and expensive to dump. They are normally treated to recover relatively coarse aluminium pieces (more than 1 to 2 millimetres), but require further treatment to recover fine aluminium and reduce toxicity before disposal.

A multi-disciplinary CSIRO team used many specialised techniques to analyse the chemistry and mineralogy of these components to devise practical recovery methods.

The first of these involved wet grinding and screening the dross to recover aluminium flakes, which make up between four and 16 per cent of drosses. The flakes are readily recycled to the melting process.

"When we grind dross, the soft, malleable aluminium particles are flattened, while the brittle, non-metallic particles are ground to a finer size and

can be screened out," explains CSIRO Minerals Honorary Fellow Jim Woodcock.

"We can get as much as 90 per cent recovery in a product assaying 90 per cent aluminium metal."

The team is also developing a novel flotation process, in which they treat the screen undersize in a flotation cell – after first adding selected reagents – to recover fine aluminium particles. The fine metal can be used as a deoxidising agent in steel making.

"So a significant amount of metal can be recovered just by fitting a simple add-on flotation stage to an existing plant," says Mr Woodcock.

The researchers then turned their attention to decomposing the aluminium nitride and carbide in dross through wet treatment.

These compounds react with water to emit noxious gases; complete reaction of these components would reduce the toxicity of the dross before disposal.

Tests showed treatment of dross with an aqueous solution of sodium hydroxide decomposed over 80 per cent of the aluminium nitride after four hours of agitation.

"The chemistry of the process is very complex," says Mr Woodcock.



A SCANNING ELECTRON MICROSCOPE IMAGE OF WET GROUND ALUMINIUM DROSS SHOWS THE FLATTENED ALUMINIUM METAL AS THE LIGHT GREY PHASE. SOME OF THE METAL APPEARS AS TWO LARGE DISKS (TOP RIGHT AND BOTTOM LEFT).

IMAGE: MARK POWNCEBY

"We are continuing with this work and seeking further support from the aluminium and recycling industries."

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Green Processing



OPEN SPACE

JOHN RANKIN

CHIEF SCIENTIST,
CSIRO MINERALS

SUSTAINABLE development is the major challenge facing the world today. Usually defined as the ability to meet the needs of the present without jeopardising the needs of future generations, sustainable development requires continued supply of metals and other materials needed by society. Solving the dilemma of the increasing demand for materials and the environmental and social impact of their production and use is the key long-term issue facing the minerals industry.

Fortunately, there are major opportunities for reducing the environmental impact of metal production while also providing social and economic

benefits through 'green' processing. For example, individual operating sites can significantly reduce the consumption of energy, water and reagents and the release of emissions through implementing cleaner production principles such as optimising the use of resources, input substitution, process modification, and on-site recycling. And, by linking with other industries, operations can become part of an industrial eco-system where products and by-products of one operation serve as raw materials and reagents for other operations, thereby reducing the total volume of waste and emissions.

Also, step improvements in environmental impact can be achieved through novel technologies such as recovering heat from molten slags, modifying slags so they can be used in cement production, and using bulk waste materials like red mud to produce value-

added products. Even more radical step changes would involve eliminating energy-intensive and waste-producing steps in processing. Comminution, for example, could be eliminated by developing technologies to selectively treat unliberated minerals.

Many solutions are cost effective: adding value to wastes or using wastes as feedstock in other processes can be more economically attractive than disposing of wastes in landfill.

These solutions also benefit the community as they result in a cleaner environment and new industries and jobs.

The research required to meet the challenge of green processing draws traditional disciplines and capabilities together in novel and interesting combinations, to tackle problems perceived through the sustainable development prism.

Planning for residue management in Alcoa with help from our community



LEADER'S FORUM

VANESSA GUTHRIE

SUSTAINABILITY MANAGER,
ALCOA WORLD ALUMINA
AUSTRALIA

Q: WHY is it important to Alcoa to involve the community in eco-efficiency and waste reduction initiatives?

A: SUSTAINABILITY underpins every decision we make in Alcoa – it is critical to our business strategy. Delivering business value for the benefit of all our stakeholders – our employees, communities, customers, suppliers and shareholders – is the core of our sustainability approach.

As the world's leading producer of aluminium and alumina, success in sustainability for Alcoa lies in thinking differently about the way we process bauxite and manage the outputs.

Part of thinking differently includes changing how we respond to and meet the increasing expectations of communities regarding our operations management.



ALCOA WORKERS IN AUSTRALIA COLLECTING NATIVE SEED AS PART OF A MINE REHABILITATION PROJECT. ALCOA IMAGE – USED WITH PERMISSION.

At our refining operations in Western Australia, we have responded to this increasingly important aspect of sustainability by establishing community Stakeholder Reference Groups.

These groups include representatives of state and local government, near neighbours and local community interest groups, and have been established to provide input to our plans for emissions reduction, operations expansion and

upgrade, and residue management.

In residue management at Pinjarra and Kwinana, the Stakeholder Reference Group has provided recommendations to Alcoa on the long-term management of our residue storage areas. This community engagement has produced much improved long-term residue management plans which include targets that are consistent with the communities' expectations.

Targets such as the size and shape of footprint, location of new residue drying areas, reduced volume of residue stored and final land use requirements have helped us to set clear, quantifiable commitments.

These promote innovative solutions and deliver reduced environmental impacts, more efficient use of resources and add business value by converting waste to valuable product.

Involving our communities in our business decisions therefore delivers better value to both the community and Alcoa – sustaining our business for generations to come.

Miners are good minimisers

By **MICHAEL WEIR**
Senior Resources Writer,
The West Australian

THE average punter in the street may not think recycling and mining go hand in hand. But the fact is the mining industry is a leader in the use of recycling and waste management.

Think of a mine site 1000 kilometres from nowhere in the middle of the West Australian outback. There isn't a regular rubbish collection service out there.

And if you have a camp with 500 people, that can generate a lot of waste. Mining companies, and indeed the service industries that so often run and manage mine camps, have become very adept at firstly minimising waste through recycling and then managing what requires disposal.

Walk around any mine workshop or lay-down yard and you also get a good indication of the extent to which recycling is undertaken.

There are usually separate cordoned-off areas for wood, pallets, batteries, oil, rubber tyres, plastic containers, iron and

steel, aluminium, cardboard – all waiting either for re-use on site or collection by a recycling contractor. I would doubt many households would go to that degree of trouble to separate and sort their rubbish.

Then there are the big processing plants, the engine room of any mining operation. Most of these plants are heavily reliant on water as part of the treatment process, but it is usually recycled and re-used.

Engineers, metallurgists and other scientists are constantly looking for new ways to treat ores to reduce the amount of waste generated.

Then there are the plants themselves. With a brand new plant costing anywhere between \$50 million and \$500 million, they are not something that companies are very quick to chuck out.

There is an active market in second-

hand treatment plants both in Australia and overseas. Many a small mining project has been made economic through the cost reductions achieved by using entirely second-, and even third-hand, equipment. Crushers, grinding mills, tanks and other equipment usually have a useful life much longer than the average mining project.

And let's not forget mining tenements. The current boom in junior exploration floats has thrown up a whole raft of old projects packaged up in new companies.

That is not a bad thing. Many major discoveries have been made on ground that may well have been worked by numerous parties over as much as 100 years. But a new set of eyes, a new philosophy, a new way of thinking and different interpretation of existing data is often all that's needed to unlock the lucrative secrets of the earth.

Scientists are constantly looking at new ways to treat ores