Alumina Market Research

INTRODUCTION

Australia and China are the world's largest producers of alumina (aluminium oxide). In 2007-2008, 19.4 million tonnes of alumina were produced from Australia's seven refineries using the Bayer process (ABARE estimate). This represents around 23% of world production. The value of Australia's alumina exports (15.7 million tonnes) was A$5.8 billion (ABARE estimate).

The Parker Centre has strong support from the alumina industry and allied companies. Alumina producers and engineering companies/industry suppliers make up 12 of the Centre's 19 Industry Participants.

The four principal alumina companies in Australia – Alcoa World Alumina, Billiton Aluminium Australia, Rio Tinto Alcan and Queensland Alumina – are all Industry Participants in the Parker Centre. Overseas alumina producers Aughinish Alumina and Norsk Hydro are also Industry Participants. Collectively these six companies produce approximately 55% of the world's alumina.

The Bayer process for extracting alumina from bauxite ore produces the majority of the world's alumina. The Bayer process involves the dissolution of the aluminium oxy-hydroxide minerals in bauxite ore using hot concentrated caustic solutions. The aluminium-laden liquor is separated from the waste solids (primarily iron oxides and silicates) before the aluminium is recovered as gibbsite (aluminium hydroxide, also called alumina trihydrate) by seeding and cooling the liquor. The final step in the process is calcination of the gibbsite ($Al_2O_3.3H_2O$) to alumina (Al_2O_3) by heating.

Being a mature industry, there is an on-going need for process improvements and new technologies. The alumina industry had considerable input into the Parker Centre's current alumina project portfolio, which was designed to address six of the 12 areas identified by the industry in the Alumina Technology Roadmap as priority areas for R&D to 2020.

ALUMINA MARKET LEADER:

DR CHRIS VERNON

(CSIRO MINERALS)

The Centre's alumina research includes CRC-funded research projects; pre-competitive, multi-sponsored AMIRA projects and one-to-one company-specific projects.

This research involves 40 full-time equivalent research staff, drawn from all four of the Centre's Research Participants and a range of disciplines. These researchers include chemists, fluid dynamicists, chemical engineers, process engineers and physicists. They are supported by a unique array of Bayer-specific and general research equipment.

Parker Centre alumina researchers are collaborating with researchers from the Institute of Chemical Technology (Czech Republic), GTT-Technologies (Germany), Université Blaise Pascal (France), Universität Regensburg (Germany), the University of Melbourne, Monash University, RMIT University, CSIRO Land & Water, CSIRO Materials Science & Engineering and CSIRO Mathematical & Information Sciences.

ALUMINA RESEARCH CAPABILITIES

- characterisation of bauxite mineralogy
- bauxite processing assessments
- impurity removal technologies
- Bayer process chemistry
- studies of solution properties and solution chemical species
- flocculation
- characterisation of surface processes: surface properties, adsorption behaviour and inter-particle forces
- thickener design and performance issues
- alumina product strength and quality
- precipitation technology
- computer modelling: molecular modelling, modelling using computational fluid dynamics and process models
- environmental issues, including residue treatment.

ALUMINA RESEARCH AREAS

The Centre's alumina research includes CRC-funded projects covering the red-side and the white-side of an alumina refinery, solid-liquid separation, impurity issues, fluoride speciation, scale and environmental issues.

Further details of the specific research in each of the CRC-funded projects are provided in the following list. The Centre also undertakes a wide range of other projects, many of which are confidential projects with companies in the alumina industry.

- Red-side technology research is contributing to two Parker Centre activity themes (Breakthrough Technologies and Education), and includes:
  - bauxite characterisation
  - bauxite beneficiation
  - predicting bauxite processing behaviour
  - desilication and digestion of bauxite ore, flashing and lime chemistry
  - process options for high silica bauxites, including acid routes
  - thermodynamics of acidic aluminium/iron solutions relevant to acid processing routes.

- White-side technology research is contributing to three Parker Centre activity themes (Process Fundamentals, Technology Transfer and Education), and focuses on:
  - options for increasing gibbsite (alumina trihydrate) precipitation yield
  - precipitation kinetics models describing the relationship between precipitation rates and process variables
  - modelling inhomogeneously mixed industrial precipitators
  - secondary nucleation and management of fines
  - alumina strength and breakage behaviour (product quality)
  - simulation of a precipitation circuit.

- Research on solid-liquid separation is contributing to three Parker Centre activity themes (Process Fundamentals, Technology Transfer and Education), and includes:
  - aggregation processes
  - thickening of residue
  - relating suspension properties, solution properties and reagent adsorption to inter-particle interactions and hence dewatering behaviour
  - modelling of all aspects of the thickening process
  - dewatering issues in other markets.

Mr Andrew Brent, an AMIRA P266E "Improving Thickener Technology" project researcher, with the pilot thickener feedwell used for pilot-scale validation of predictions from the project's population balance-computational fluid dynamics (PB-CFD) feedwell model.

- Impurity issues research is contributing to all four Parker Centre activity themes (Breakthrough Technologies, Process Fundamentals, Technology Transfer and Education), and includes:
  - sodium oxalate crystallisation and stability
  - removal strategies for organic impurities
  - removal strategies for inorganic impurities
  - fluoride speciation in Bayer liquors
  - scale prevention or minimisation.

- Bayer environmental research is contributing to two Parker Centre activity themes (Process Fundamentals and Education), and includes:
  - bauxite residue disposal and re-use options
  - understanding causes of emissions (eg odours, trace metals and dust) and formulation of options to control such emissions.

- Research on risk communication is contributing to two Parker Centre activity themes (Technology Transfer and Education), and is focusing on:
  - factors affecting community reaction to the proposed introduction of new hydrometallurgical processing technologies and new uses for by-products
  - communication with the community about new processing technologies and new by-product applications.

Alumina Market Research

INDUSTRY BENEFITS

The potential benefits to the minerals industry of the Centre's alumina research include:

BENEFITS ARISING FROM BREAKTHROUGH TECHNOLOGIES RESEARCH

- innovative processing technologies for extracting alumina from bauxite ores containing high levels of silica, which would potentially convert vast untapped bauxite deposits into valuable assets
- processes for removing inorganic and organic impurities from Bayer liquors, leading to improved efficiency of Australian alumina refineries
- improved technologies for reducing the rate of scale formation on refinery processing equipment
- technical solutions for decreasing the release of volatile organic compounds (cause odours) into the air during alumina processing
- strategies to remove minor elements (trace heavy metals) from the Bayer process and from residues
- decreased dust formation in bauxite residue storage areas
- economic options for bauxite residue re-use.

BENEFITS ARISING FROM PROCESS FUNDAMENTALS RESEARCH

- improved digestion and desilication procedures, including procedures better tailored to the properties of the bauxite ore being processed
- better strategies for seeding alumina refinery precipitators with seed crystals of gibbsite to promote gibbsite crystal growth
- increased gibbsite yields from precipitation in the Bayer process
- improved design and operation of industrial gibbsite precipitators
- better quality smelter grade alumina product with improved properties, such as greater strength
- improved performance of gravity thickeners (resulting from increased fundamental knowledge and computer modelling), allowing processing plants to increase throughput, save water, reduce capital and running costs and obtain a purer mineral slurry for the next processing stage
- a greater capacity to select flocculants for specific process outcomes (eg clarity, throughput, paste disposal) in solid-liquid separation
- improved recovery of water from tailings treatment, thereby reducing overall water consumption
- reduced environmental impact from tailings disposal through improved utilisation of paste technologies
- increased and more timely uptake of new processing technologies and new uses for processing by-products, through a greater capacity to evaluate and address community risk factors
- an enhanced industry skill base achieved through technology transfer and education & training activities.

Mr Mitesh Chauhan, a chemical engineering student at the University of Cape Town in South Africa, in one of the Parker Centre's alumina research laboratories. Mitesh was one of the 11 participants in the Centre's Summer 2007-2008 Student-Industry Research Program. He undertook a research project with the "Bayer White-Side Technology" project team on the effect of ultrasound on gibbsite precipitation.

Alumina Market Highlights 2007-2008

TECHNOLOGY TRANSFER & IMPACT

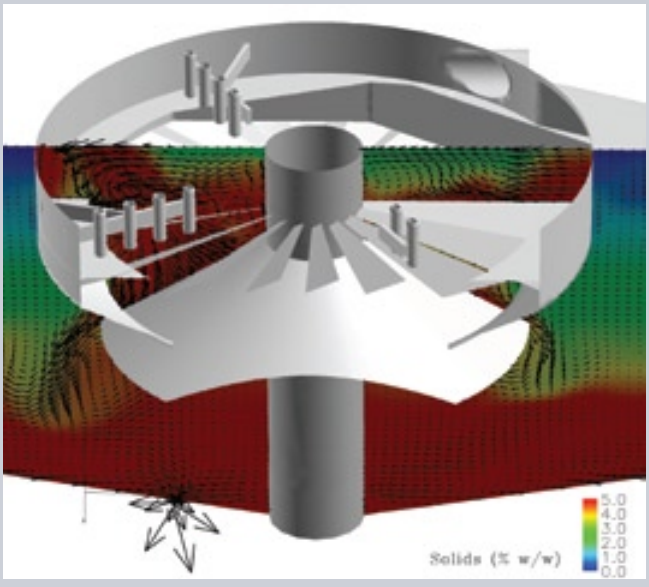
- Stand-alone gibbsite precipitation modelling software (incorporating the most advanced gibbsite precipitation kinetic models) was developed to enable industrial clients to simulate continuous well-mixed gibbsite precipitators.
- Increased understanding of silica fundamental chemistry was communicated to other researchers and industry via a presentation on research on quartz attack in Bayer digestion at the TMS (The Minerals, Metals & Materials Society) 2008 Annual Meeting in New Orleans, USA. A follow-up paper will be submitted to a peer review journal.
- A novel thickener feedwell design was developed. Modelling suggests that the new design offers a greater capacity to cope with throughput variations. Pilot-scale validation has been conducted, a patent application submitted and a full-scale trial is about to commence.
- Workshops on flocculation and thickening were delivered for three sponsors of the AMIRA P266E "Improving Thickener Technology" project. All sponsors received expanded and improved versions of the project's Rake Torque and Pipe Flocculation models.

ADVANCING THE SCIENCE

- Papers were published on flocculant ageing, the use of turbulent pipe flow to study polymer-bridging flocculation and raking in gravity thickeners. The third paper represents the first published detailed study of the flow patterns and solids delivery to the underflow for different rake configurations.
- A new finite-element method based precipitation modelling tool, incorporating gibbsite crystal growth and secondary nucleation kinetics, was developed. The finite element approach delivers a superior accuracy of the model system.
- An alternative technique (based on full Rietveld mathematical analysis) was developed for quantitative alumina phase analysis and was validated against an existing empirical technique.
- The full-scale pipe reactor was used to characterise the flocculation kinetics (rates) for seawater-neutralised bauxite residue at a site belonging to a major sponsor of the AMIRA P266E "Improving Thickener Technology" project. In addition, studies using hematite [iron(III) oxide] as a model substrate provided insights into the relative impacts of surface chemistry and flocculant properties on the project's population balance (PB) model for flocculation.

DEVELOPING RESEARCH CAPABILITY

- A multiple gamma-ray source instrument for advanced permeability characterisation was completed and tested with flocculated sediments prepared under controlled shear conditions (both Couette and turbulent pipe flow). The new instrument offers greatly increased sensitivity and has already provided unprecedented quantification of the onset and subsequent closure of channels within sedimenting columns.
- High performance liquid chromatography (HPLC) and nuclear magnetic resonance (NMR) methods for analysing organics in caustic solutions were developed. Final validation of these quantitative methods is well advanced.
- The tender for a Commonwealth-funded "Bauxite Residue" project as a key Australian project within the Asia-Pacific Partnership on Clean Development and Climate was successful. The project commenced in early 2008.
- Computational fluid dynamics (CFD) modelling of thickener rake action produced the first estimates of the shear rates experienced within a bed near rake blades. Parallel studies underway, in collaboration with researchers at the University of Melbourne, aim to quantify the impact of such shear on aggregate densification and breakage.



The AMIRA P266 "Improving Thickener Technology" project is now using advanced computational fluid dynamics (CFD) mesh generation tools and CAD to-mesh, allowing complex thickener feedwell geometries to be modelled.

Bayer Red-Side Technology

OBJECTIVES

Alumina refineries use different variations of the Bayer process, with the variation utilised at a particular refinery to a large extent being tailored to the mineralogy of the bauxite ore being processed. Differences can range from the temperature of extraction to clarification technologies and organic removal processes. In-depth mineral characterisation of bauxites can point to the most effective processing options and can also be used to examine bauxite beneficiation techniques for improving the ore quality prior to processing.

The world in general, and Australia in particular, is running out of high quality (low silica) bauxite ores. To maintain its competitive edge, the Australian alumina industry needs the development of ways to economically process high silica bauxites.

This project aims to address these challenges for industry by:

- developing a better understanding of mineral compositions, associations and liberations, and likely processing behaviours (especially in desilication and extraction), of new and existing bauxites
- developing options for the beneficiation of Australian bauxites
- determining and assessing options for the economic processing of high silica bauxites by Bayer and non-Bayer technologies, including acid routes.

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OUTPUTS

- Work has concentrated on two possible processes for the economic processing of high silica bauxites. Patent specifications for two patent applications for these processes are in preparation.
- Understanding of silica fundamental chemistry was advanced. A paper on quartz attack in Bayer digestion was presented at the TMS (The Minerals, Metals & Materials Society) 2008 Annual Meeting in New Orleans, USA in March 2008. Work on aspects of desilication will be presented at the 8th International Alumina Quality Workshop (AQW 2008) in Darwin, Australia in September 2008.
- Some of the research on fundamental desilication product (DSP) nucleation and titanate solubility will also be presented at the AQW 2008.
- Several confidential bauxite characterisation projects were undertaken for clients. Other industry-funded confidential projects included a project that examined the causes of alumina reversion in a refinery's washers and a project that examined the equilibrium calcite solubility in digestion.

Bayer White-Side Technology

OBJECTIVES

An important driver in the alumina industry is to increase the yield and rate of the gibbsite precipitation stage in order to boost the overall productivity of a refinery. The precipitation process is controlled by the interplay between crystal growth, agglomeration and nucleation. Recent work has significantly increased the fundamental understanding of some of these sub-processes. However, this understanding needs to be expanded and then utilised in advanced precipitation process modelling, design and optimisation.

The precipitation stage also plays a pivotal role in determining the quality of the resultant smelter grade alumina (SGA), which is characterised by parameters such as purity, particle size distribution and particle strength. More accurate relationships between SGA quality and chemical/morphological properties of the preceding gibbsite are required for further improvement of SGA product quality.

This project focuses on achieving the following objectives:

- improving fundamentally-based mathematical models for gibbsite crystal growth, agglomeration and secondary nucleation kinetics (rates)
- modelling the relationship between gibbsite quality and process conditions, and exploring ways to improve yield and quality
- identifying the effects of precipitation and calcination conditions on alumina properties such as strength
- improving the ability to model large-scale precipitators, which are commonly more complex to model due to their heterogeneous nature
- implementing advanced developments to deliver to pre-competitive and 1:1 industry projects.

OUTPUTS

- A new finite-element-based precipitation modelling tool was developed. The modelling tool features a graphical user interface and incorporates gibbsite crystal growth and secondary nucleation kinetics. The finite element approach delivers a superior accuracy for the model's solution.
- A stand-alone gibbsite precipitation modelling software program was developed, which can be delivered to clients to simulate continuous well-mixed gibbsite precipitators.
- Laboratory controlled-cooling precipitation experiments were conducted to demonstrate a key impact of the precipitation temperature profile in determining the quality of the gibbsite precipitation product.
- A method for two component (oxalate and gibbsite) precipitation experimentation was developed, and used to undertake a number of experiments characterising equilibrium properties of this system under conditions relevant to the Bayer process.
- Existing differential techniques for estimating precipitation kinetics from experimental data were extended to enable analysis of precipitation data from a novel semi-continuous precipitator.
- A modified method for short-term calcination of gibbsite using a new calcination furnace was developed and validated in terms of its sensitivity, reproducibility and spatial variability.
- An alternative technique, based on full Rietveld mathematical analysis, was developed for quantitative alumina phase analysis and validated against an existing empirical technique.

AMIRA P507C Project: Thermodynamic Characterisation of Organics in Bayer Liquors

OBJECTIVES

The AMIRA P507A "Prediction & Measurement of the Physicochemical Properties of Bayer Liquors" project acquired physicochemical data to allow more informed decisions on plant design and operational conditions. The P507B project aimed to further enhance the computer models resulting from P507A by characterising (to temperatures far higher than have hitherto been possible) the thermodynamic behaviour of the chemically aggressive, concentrated electrolyte solutions ('liquors') used in alumina refining via the Bayer process.

Measurements of the heat capacities and densities of such solutions to 300°C were used to develop robust computer models to describe and predict (over the range of concentrations and impurity levels important to the alumina industry) these properties and others that can be derived from them. The P507B project was completed in December 2006 but an extension project was negotiated.

This latest project in this series, the four-year AMIRA P507C project, commenced in June 2007 and is investigating the thermodynamic properties of Bayer process liquors containing various organic impurities. This will involve the study of redox reactions in highly alkaline solutions containing humic substances, the outcome of which will provide knowledge of the identity and abundance of organic species in Bayer liquors. A fundamental basis for flowsheet optimisation will also be delivered to assist in improving impurity control, product recovery and process monitoring.

OUTPUTS

- A literature review identified approximately 35 low molecular weight organic acids in Bayer liquors as being of interest.
- The long-term reaction of low molecular weight organics in caustic solution at 90°C and 180°C was investigated in duplicate.
- A reaction apparatus designed to hold up to 24 reaction vessels at 90°C was developed. Analyses were performed to determine reactions after up to 36 days.
- The project's existing isopiestic apparatus was modified for high temperature studies (180°C) and is in use. A second series of reactions of organics at 180°C was set up and analyses have been partially performed.
- High performance liquid chromatography (HPLC) and nuclear magnetic resonance (NMR) methods for the analysis of organics in caustic solutions were developed. Final development and validation of these quantitative methods is well advanced.
- A pattern of stability of various organic compounds in hot caustic solution has begun to emerge. Organics can now be classified as 'rapidly decomposing', 'slowly decomposing' or 'no sign of decomposition' (at up to 36 days of reaction so far).
- Plant root samples have been extracted in caustic solution at boiling point (approximately 108°C) for one hour, three hours and 24 hours: analysis of the samples has started and is still ongoing.

AMIRA P266E Project: Improving Thickener Technology

OBJECTIVES

Gravity thickeners are a crucial piece of equipment used for large scale solid-liquid separation in most mineral processing operations. There is significant scope for thickener improvement in most applications. The challenges are to understand how to increase throughput, enhance performance (better overflow clarity, higher underflow density and flocculant savings), reduce costs and improve operational stability.

The AMIRA P266 series of projects has considerably advanced the understanding of the fundamental processes occurring within gravity thickeners. This understanding has allowed the project team to identify key factors affecting full-scale thickener performance and to modify design and operating conditions to improve performance in processing plants. The P266E project is the sixth project in the series.

This project aims to extend the ability to improve full-scale thickener performance by refining and expanding some of the concepts developed to date, as well as applying the current skills to new thickener technology issues. A key objective is to build a holistic computer model that captures the processes within an entire thickener: this will involve coupling the team's well-established feedwell model to others being developed by the team that describe sedimentation, consolidation and raking.

OUTPUTS

- The full-scale pipe reactor was used to characterise the flocculation kinetics (rates) for seawater-neutralised bauxite residue at a major sponsor's site. A much larger program of studies with hematite (iron(III) oxide) as a model substrate was also completed, which has provided insights into the relative impacts of surface chemistry and flocculant properties on the project's population balance (PB) model for flocculation.
- A small-scale test for rapidly estimating the flocculation kinetics parameters required for PB-computational fluid dynamics (CFD) feedwell optimisation was developed and tested successfully at two operating sites.
- Refinement of the framework for the PB-CFD feedwell model was largely completed, providing much reduced convergence times and the capacity to enter more complex geometries. The framework now exists for full thickener modelling, with some aspects of bed behaviour captured, but an improved sedimentation model is still required.
- CFD modelling of rake action produced the first estimates of the shear rates experienced within a bed near rake blades. Parallel studies in collaboration with the University of Melbourne are seeking to quantify the impact of such shear on aggregate densification and breakage.
- The use of PB-CFD to establish the effect of feedwell design elements was extended to closed feedwell configurations, baffles and dilution slots.
- A novel feedwell design that modelling suggests offers a greater capacity to cope with throughput variations was developed. Pilot-scale validation was conducted, a patent application was submitted and a full-scale trial will commence shortly.
- The Knowledge Base on flocculation and thickening (accessible to sponsors through the project's website) was substantially revised and expanded. Rake torque and pipe flocculation process models were also significantly enhanced.
- Targeted workshops on flocculation and thickener technology were run at the sites of four different sponsors.
- The project concluded with the Final Sponsors Meeting in Melbourne in May 2008. At this meeting, a draft proposal for an extension project (the P266F project) was discussed and endorsed by the existing sponsors. P266F will place a greater emphasis on experimental and modelling activities required for the development of the first fully predictive sedimentation model, which is a necessary step towards the goal of full thickener modelling. Marketing of the P266F project has begun.

Solid-Liquid Handling

OBJECTIVES

At least one stage of solid-liquid separation can be found in almost all mineral processing flowsheets. Economic and environmental concerns ensure that there is always pressure for more efficient dewatering, either through increased throughput, reduced capital footprints, cleaner overflows, higher underflows or paste disposal.

This project will continue past research in the area of flocculation and thickening which focused on the fundamentals of aggregation of fine particles in solid-liquid suspensions. The generic knowledge developed in previous work has already been successfully applied to solving plant-based problems (using the AMIRA P266 projects as a bridge), through changes to flocculation practice or modifications to feedwell designs.

This project aims to:

- substantially enhance the fundamental understanding of aggregate structures and properties over a wide range of solids concentrations, and to thereby develop clear relationships between initial aggregation conditions and dewatering performance at different stages
- develop and validate (lab, pilot and full-scale) advanced models that describe physical behaviour representing each dewatering process (flocculation, sedimentation, consolidation and sediment raking)
- utilise the knowledge gained to enhance full-scale solid-liquid handling performance.

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OUTPUTS

- A multiple gamma-ray (γ-ray) source instrument for advanced permeability characterisation was completed and tested with flocculated sediments prepared under controlled shear conditions (both Couette and turbulent pipe flow). The new instrument offers greatly increased sensitivity and has already provided the unprecedented quantification of the onset and subsequent closure of channels within sedimenting columns.
- A single γ-ray source instrument was also installed on a continuous tall column system to provide on-line profiling beds up to several metres in height (in collaboration with Monash University).
- Papers were published on flocculant ageing and the use of turbulent pipe flow to study polymer-bridging flocculation.

Impurity Issues

OBJECTIVES

The majority of alumina refineries around the world, and all of those in Australia, have two major problems with impurities. Firstly, crystalline scale deposits form on almost every piece of processing equipment, which reduces the useful operating capacity of pipes and vessels and severely affects heat exchange properties. Secondly, soluble impurities, both organic and inorganic, limit the productivity of the Bayer liquor. Sodium oxalate, a by-product of the breakdown of organic impurities, adversely affects liquor productivity and product quality. In addition, a number of organic compounds in Bayer liquors are very volatile and could pose environmental problems.

The consequences of impurities in Bayer liquors are reduced productivity and increased processing and capital costs, which amount to well over A$1 billion per year in Australia alone.

To address the problems caused by impurities, this project aims to:

- discover better methods for decreasing the impact of scale in the Bayer process
- understand nucleation of scale on metal surfaces in order to develop strategies to prevent or delay scale formation
- investigate reactions and deportment (location) of organic impurities, and technologies for removing organics from Bayer liquor or directly from bauxite
- study factors affecting sodium oxalate precipitation and develop techniques to control this precipitation
- increase understanding of the deportment, types of chemical species and reactions of certain inorganic impurities (especially fluoride), and how their concentrations might be decreased.

OUTPUTS

- A strong fundamental understanding of mild steel surface chemistry in caustic solutions was developed using a combination of electrochemical and surface spectroscopy techniques.
- Thermodynamic modelling of dissolved impurity species such as fluoride and sulfate was improved and capabilities in modelling organic species were developed.
- The capability to investigate wet oxidation of Bayer liquors under industrial conditions was developed and mechanistic studies commenced. This work was presented at the TMS 2008 Annual Meeting in New Orleans, USA in March 2008.
- Collaborative projects were established with RMIT University in Melbourne on co-oxidation of model Bayer organics.
- A new facility was designed in which the oxidative environment in Bayer liquors, including pO_2 (partial pressure of oxygen), can be well controlled and measured. The facility has been constructed and delivered.

Bayer Environmental Issues

OBJECTIVES

Environmental pressures are putting tighter constraints on residue disposal and emissions (mainly impurities) from Bayer alumina refineries.

Airborne emissions include volatile organic compounds and also volatilised heavy metals from the digestion, flash train and liquor burning stages. Increased knowledge of the deportment (location) of impurities through the Bayer process and into the atmosphere is needed to be able to develop strategies to reduce emissions and find containment alternatives.

Bauxite residue disposal creates an ongoing requirement for larger storage areas, with the problem of caustic containment. Residue storage and treatment options for producing a more benign material would benefit the industry. Development of methods for further processing existing and future residue to produce valuable by-products would not only have economic value but also environmental value through reducing the quantity of residue requiring storage.

The research in this project aims to:

- understand the deportment of species that ultimately give rise to airborne emissions, and develop mitigation strategies for these emissions
- determine the effectiveness of current residue treatments to prevent caustic leaching and improve handling
- develop novel processes to ameliorate residue or economically produce value-added products from it.

OUTPUTS

- The work on understanding the mechanism of fugitive dust formation from bauxite residue disposal areas was presented at the TMS 2008 Annual Meeting in New Orleans, USA in March 2008.
- An article was published in the April 2008 issue of the *Light Metal Age Magazine* on the development of a Quantitative Sustainability Assessment Tool for Bauxite Residue Management in the AMIRA P772 "Bauxite Residue: Sustainability Measures of Improvement" project.
- Further progress was made on modelling the moisture and solute transport and the equilibrium chemistry in the drying process for bauxite residue.
- The impact on residue dust formation from neutralisation by carbonation, seawater and bitterns treatment was examined with further greenhouse tests.
- The Parker Centre successfully tendered for the Commonwealth-funded "Bauxite Residue" project as a key Australian project within the Asia-Pacific Partnership on Clean Development and Climate. This project commenced in early 2008.
- Several leach test methods were compared in an industry-funded project, with one method demonstrated to be superior to a proposed European standard.

Risk Communication

OBJECTIVES

Community perceptions can have significant implications for the uptake of technical processes by the minerals industry. Public concerns about a new processing technology and/or a new use for a processing by-product can result in negative publicity, delays in obtaining regulatory approval, increased litigation, substantial damage to company reputation and, in extreme cases, loss of the 'social license to operate'.

Research literature on 'risk communication' shows that public perceptions of risks do not necessarily correspond with objective risks (ie the 'scientific evidence'). Community perceptions of, and responses to, innovations are shaped by various non-technical factors, such as personal value systems, previous experiences, levels of trust in different information sources and openness to change.

The challenge for the minerals industry is to identify and understand the factors that affect community reaction to a proposed new mineral processing technology or by-product use. Understanding these factors will help the industry and research scientists determine how best to incorporate "social risk" in project planning and technology development, thereby facilitating public acceptance through appropriate and timely communication and the inclusion of design and implementation strategies that aim to address and ameliorate public concern.

This project aims to assist industry personnel and researchers with these challenges by:

- analysing past experiences related to risk communication and the implementation of new technologies in the minerals and other industries
- developing a framework for assessing and managing social risks associated with implementing new technology in the minerals industry, and then conducting industry trials of the framework
- developing guidelines on strategies for risk communication with communities and other external stakeholders about new hydrometallurgy technologies and by-product uses.

OUTPUTS

- The triggers that give rise to community concern, and the milestone events that go toward shaping the relationship between community and industry, were identified.
- An understanding of the mechanisms and influencers of risk evaluation (from the perspectives of research scientists, industry representatives and community members) was gained.

Alumina Market Research Portfolio

Project	Research Team	Research Collaboration	Project Duration	Activity Theme Contribution
CRC-funded Projects				
Bayer Red-Side Technology (incorporates the New Bauxite Processes component led by Peter May)	Peter Smith (Project Leader), Michael Davies, Lynette De Silva, Erich Koenigsberger, Peter May, Christine Rae, Douglas Todd, Bingan Xu, Kamila Dudek (Honours student), Ivan Raguzin (Student-Industry Research Program student), Jessie Walsh (Honours student)	CSIRO Minerals, Murdoch University, CSIRO Minerals' CFD Group, CSIRO Minerals' High-Temperature Processing Group, GTT-Technologies (Germany)	2005-2008	Breakthrough Technologies Education
Bayer White-Side Technology	Iztok Livk (Project Leader), Parisa Arabzadeh-Bahri, Peter Austin, Dianne Bedell, Andrey Bekker, Neil Francis, Bee Gan, Alex Heath, James Hockridge, Tian Li, Judy McShane, Mark Schibeci, Denise Vassallo, Mitesh Cauhan (Student-Industry Research Program student)	CSIRO Minerals, Murdoch University	2005-2008	Process Fundamentals Technology Transfer Education
Solid-Liquid Handling	Phillip Fawell (Project Leader), Fiona Benn, Andrew Brent, John Farrow, Neil Francis, Alton Grabsch, Alex Heath, Tuan Nguyen, Andrew Owen, Murray Rudman, Peter Scales, Kosta Simic, Darrin Stephens, Jean Swift (retired October 2007), Shane Usher, Steven Wang (Student-Industry Research Program student)	CSIRO Minerals, CSIRO Materials Science & Engineering, CSIRO Mathematical & Information Sciences, Monash University, University of Melbourne	2005-2008	Process Fundamentals Technology Transfer Education
Impurity Issues (incorporates the Fluoride Speciation component led by Peter May and the Scale component led by Franca Jones)	Joanne Loh (Project Leader), Greta Brodie, Ryan Chester, Allan Costine, Glenn Hefter, Franca Jones, Erich Koenigsberger, Melissa Loan, Peter May, Jonathon Morton, Tomoko Radomirovic, Mike Thornber, Bill van Bronswijk, Chris Vernon, Felicia Lee (PhD student), Kamila Dudek (Honours student), Sounam Tashi (Honours student)	CSIRO Minerals, Curtin University, Murdoch University, Curtin Water Quality Research Centre, RMIT University	2005-2008	Breakthrough Technologies Process Fundamentals Technology Transfer Education
Bayer Environmental Issues	Craig Klauber (Project Leader), Neil Francis, Markus Gräfe, Nicole Harwood, Renee Hockridge, Greg Power, Peter Smith, Chris Vernon (CSIRO Minerals)	CSIRO Land & Water	2005-2008	Process Fundamentals Education
Risk Communication	Cath Pattenden (Project Leader), David Brereton (University of Queensland)		2007-2009	Technology Transfer Education

Project	Research Team	Research Collaboration	Project Duration	Activity Theme Contribution
Collaborative AMIRA Projects				
AMIRA P266E Project: Improving Thickener Technology	John Farrow (Project Leader), Peter Austin, Fiona Benn, Andrew Brent, Anh Bui, Phillip Fawell, Neil Francis, Alton Grabsch, Alex Heath, Warren Jones, Iztok Livk, Tuan Nguyen, Andrew Owen, David Paterson, Murray Rudman, Peter Scales, Kosta Simic, Darren Stephens, Jean Swift (retired October 2007), Shane Usher	CSIRO Minerals, CSIRO Materials Science & Engineering, CSIRO Mathematical & Information Sciences, University of Melbourne	2005-2008	
AMIRA P507C Project: Thermodynamic Characterisation of Organics in Bayer Liquors	Peter May, Glenn Hefter (Project Leaders), Erich Koenigsberger, Damian Laird, Thomas Machold, Eleonora Macedi, Zoltán Paksi	Murdoch University, Institute of Chemical Technology (Czech Republic), Université Blaise Pascal (France), Universität Regensburg (Germany)	2007-2011	
AMIRA P521C Project: Modelling the Effect of SPO [Solid Phase Oxalate] on Gibbsite Secondary Nucleation	Iztok Livk (Project Leader), Dianne Bedell, Tian Li, Judy McShane, Denise Vassallo (CSIRO Minerals)		2007-2009	
AMIRA P575B Project: Influence of Thermal Transformation on Alumina Strength	Iztok Livk (Project Leader), Peter Austin, Bee Gan, James Hockridge, Mark Schibeci (CSIRO Minerals)	CRC for Sustainable Resource Processing, CSIRO Minerals	2008-2010	

Industry Collaboration

In 2007-2008, the Parker Centre's Alumina Market engaged with the following companies through collaboration and one-to-one projects:

Albian Sands Energy, Alcan Engineering, Alcan International, Alcoa World Alumina, Alumina do Norte do Brasil, AMIRA International, Anglo Platinum, AngloGold Ashanti, Aughinish Alumina, Bateman Engineering, Bechtel Corporation, BHP Billiton, BHP Billiton Nickel West, Billiton Aluminium Australia, Cape Alumina, Ciba Specialty Chemicals, Cytec Industries, Dorr-Oliver Eimco, GL & V Australia, Hatch Associates, Hydro Aluminium, Lightnin Africa, Minara Resources, Nalco, Norilsk Nickel, Outotec, OZ Minerals, Phelps Dodge Mining Company, Queensland Alumina, Reed Resources, Rio Tinto, Rio Tinto Alcan, Rio Tinto Aluminium, United Company RUSAL, West Indies Alumina Company (WINDALCO) and Zinifex

Postgraduate Projects

Project	Postgraduate Researcher	Supervisor(s) (Organisation)
Interfacial Surface Chemistry of the Bayer Process	Felicia Lee (PhD student)	Chris Vernon (CSIRO Minerals), Bill van Bronswijk (Curtin University), Gordon Parkinson (Alcoa World Alumina)
Aluminous Goethite in the Bayer Process	Fei Wu (PhD student)	Bill Richmond (Curtin University), Peter Smith (CSIRO Minerals)
Determining the Effect of Titanium on Aluminium Dissolution in Synthetic Bayer Liquors	Kamila Dudek (Honours student)	Franca Jones (Curtin University)
Investigating Aluminosilicate Formation in Synthetic Bayer Liquors	Sonam Tashi (Honours student)	Franca Jones (Curtin University), Daniel Southam (Curtin University)
Ilmenite Reactivity in Bayer Liquors	Jessie Walsh (Honours student)	Bill Richmond (Curtin University), Peter Smith (CSIRO Minerals)