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"Doing it Big Downunder" - Conference Overview: Separations Technology VI: New Perspectives on Very Large Scale Operations

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Abstract

Preamble and Introduction

“DOING IT BIG DOWNUNDER” - CONFERENCE OVERVIEW[1] SEPARATIONS TECHNOLOGY VI: NEW PERSPECTIVES ON VERY LARGE SCALE OPERATIONS

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From October 3-8, 2004 a group of the world’s leading researchers and corporate technologists gathered at Fraser Island, the world’s largest sand island and a World Heritage location, to debate future developments in separations technology. The conference, the sixth in the series of Engineering Conference International meetings on separations, concentrated on the three sub-themes of capture and reduction of greenhouse-gas emissions, the supply of economic and safe urban water and the development of low environmental footprint minerals extraction processes. All have separations requirements on the mega scale.

Australia, as host country, had a number of distinguishing characteristics. It is a major exporter of fossil fuels, being the world’s largest exporter of coal and a significant exporter of LNG to the growing markets of Asia from its vast reserves of hydrocarbons off the north west coast of the country. It is the world’s driest continent. It has a long history of minerals processing and is home to two of the world’s leading minerals companies. Technologies developed in Australia have made significant inroads into water treatment and all aspects of minerals processing.

Those present at the conference brought perspectives from the USA, Japan, Europe, China and Australia. Fraser Island, with its backdrop of migrating whales, native dingos and towering turpentine trees (exported in the early 20th century to stabilise the sides of the Suez Canal) provided the stimulation for reflective thinking. Some brief comments on the outcomes of the conference follow.

It was generally agreed that the use of fossil fuels for electric power generation will remain dominant for the next 30-50 years and that coal will continue to play an important role, despite an estimated threefold growth in international shipments of liquefied natural gas over the next two decades. Key to lowering greenhouse gas emissions from power generation will be the capture and sequestration of carbon dioxide. This will add 10-30% to the costs of power generation and will demand significant improvements in technology. Studies at the Central Research Institute for Electric Power Industry, Japan have demonstrated that the recovery of CO_2 from power station flue gas is technically feasible on the large scale and is best achieved using new generation amine absorbents.

The use of pressure-swing adsorption and pressure-temperature-swing adsorption is also possible but requires up to a 100-fold scale-up on present practice. Estimates by

[1] Non refereed contribution

the US Department of Energy (DOE) in the FutureGen project suggest $US16/tonne for CO_2 captured and a further $US 25-45/tonne for its successful sequestration using existing technologies.

Greatest hope in emission control lies with integrated gasification, combined-cycle (IGCC) technology. Here DOE has in train three key developments. The first is an ionic ceramic membrane for air separation that operates at 800-900^oC and offers a capital cost reduction of 30% and operating cost reduction of 60% over conventional cryogenic air separation technology. Since provision of enriched air is a requirement of the IGCC process, this represents an important step forward. The second is a porous ceramic membrane for hydrogen recovery from the shift gas convertor, which can operate at 300-400^oC at a separation factor of 140. The third is a process for hydrate removal of CO_2 which can achieve capture costs of $US 5-10/tonne CO_2. Separately, work is in progress to achieve short cycle times in temperature-swing adsorption systems for CO_2 removal.

These developments abroad are being paralleled in Australia by studies on high temperature ceramic and polyimide membranes and on new solvent systems for absorptive recovery. While not yet tested on other than the laboratory scale there are promising indications that Australian research will have a significant role in international developments. Local studies of the impact on recovered CO_2 purity on sequestration costs suggest that membrane permeation is perhaps more important than membrane selectivity. There is clearly scope for large scale demonstration of Australian-developed technology and for further fundamental work on high temperature separation processes. The concept of international shipments of CO_2 as backloading for LNG tankers was briefly addressed, as was the concept of such CO_2 being used for enhanced oil recovery or submerged land reclamation, providing the sub-surface geology is right.

Delegates to the conference were particularly impressed by the progress that the Singapore Public Utilities Board has made with the recycle of treated sewage in the Singapore NEWater project. Costs of treated water are half those for seawater desalination ($0.5/kL) and the capacity of the plants will be increased to 10 MegaL/day by 2005. Currently 5% of Singapore's water requirements are supplied as NEWater with one-fifth of this being directly recycled to the potable water system. A notable feature of the Singapore facility is the use of the Australian-developed Memcor microfiltration technology as the pre-treatment process for the nanofiltration step. In this way the fouling problems that dogged the massive Yuma desalination facility in the USA in the early 1990's have been avoided.

For particularly "tough" wastewaters new technologies are emerging. These include the Orica MIEX process and several other technologies relying on magnetised particles. It is clear that these technologies are rapidly replacing conventional chemical and sedimentation treatment for the separation of problem contaminants and it is reported that such pre-treatment can protect subsequent membrane plant. The design of very large scale water treatment plants is clearly undergoing a metamorphosis.

Delegates agreed that minerals processing is a demanding business, with prices for minerals declining by 2% per year and returns from the industry typically less than 5%. Quantities processed are massive and rely on well established separation processes. Australia is leading the world in developments in wet cyclone design using computational fluid dynamics and in the fundamental design of flotation equipment. The use of time-offlight secondary ion mass spectrometry to predict particle wettability holds promise of customising mineral beneficiation circuits so that comminution costs are minimised and flotation circuits operate optimally. Solvent extraction now dominates smelting in copper recovery and new solvents, including some developed in Australia, are showing promise. Interfacial contamination remains a problem and warrants fundamental studies to minimise its effect. Dewatering of flocculated suspensions is now under intensive study, with the aim of eventually moving to paste backfill of tailing ponds.

One surprising feature of the conference was the unveiling of new approaches to conventional distillation and absorption tower internals, with a new Plum Flower mini-ring developed in China outperforming established packings by 20-50% in capacity and efficiency and the ARC downcomer tray (also from China) offering 20% higher tray efficiency. These developments represent intense research effort in China to equip its burgeoning chemical industry with improved separation technology.

It was apparent that a nanotechnology approach to ceramic membrane production and to the development of tailored adsorbents holds promise of replacing conventional technologies for gas separation with bold, new alternatives. Computational chemistry is at last beginning to offer the possibility of predicting how separation and transport occurs in nanostructure arrays and hence designing arrays for optimal performance. The challenge remains of how to incorporate these developments into large-scale, functioning units that can operate with high reliability.

Perhaps the most interesting feature of the conference was the extent to which delegates from three quite different sectors found that they had many ideas to share and a recognition that future challenges in separations technology will increasingly be based on good engineering as well as clever science. As one experienced practitioner remarked: "innovative chemistry will very likely bring about the step changes in separation efficiency that we will need to cope with 21st century problems but getting these plants to work will be every bit as difficult as the challenges faced in the establishment of the petrochemical industry in the early 20th century."

The support of the Australian Academies, the Institution of Chemical Engineers, the American Institute of Chemical Engineers, and Australian industry in sponsoring the conference and in providing for the attendance of a significant group of Australia's young researchers is deeply appreciated.

Many of the papers presented at the conference were "commercial-in-confidence" in nature and were not available for inclusion in the Conference proceedings. The Co-Chairs are grateful to those authors able to share their work with a wider audience through publication in the Conference Proceedings.