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EDITORIAL

In this issue we are highlighting the work carried out at the National Centre for Industrial Microwave Processing at Nottingham University which is part of the School of Chemical, Environmental and Mining Engineering (SChEME). Amongst the numerous areas being studied at the Centre Professor Sam Kingman focuses on the treatment of rocks and oil polluted drill cuttings using microwave energy.

Other areas include thermal desorption and pyrolysis. Sam Kingman stresses that success in these applications necessitates multidisciplinary teams working closely together in order to bring to bear the various expertise needed for large scale industrial processing.

From everybody at AMPERE we wish you a prosperous New Year.

Ricky Metaxas, Editor
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THE USE OF MICROWAVE TECHNOLOGY IN THE PROCESS INDUSTRIES

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In the process industries the potential of microwave energy has been realised by many as an environmentally sound alternative to conventional heating methods. Significant numbers of publications in the area are produced each year with applications ranging from the synthesis of organic and inorganic chemicals, to the fracture of rocks, the regeneration of sorbents and the processing of waste materials.

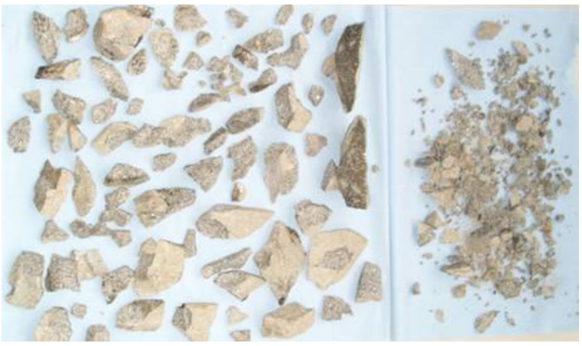
Research at The University of Nottingham has focussed upon a number of highly novel areas application areas for microwave energy, one of which is the treatment of rocks to improve the energy efficiency of comminution and hence mineral liberation. Heating large quantities of relatively low-grade ore in a microwave cavity may seem somewhat far-fetched, however a massive 5% of the worlds electrical energy output is used to grind rocks in order to liberate the valuable mineral grains from within low-grade ores. Grinding processes produce much noise and heat and are as a result very inefficient, with typically only 1% of the energy input being used to produce the micro-fractures needed to promote size reduction. Ore-feedstocks to grinding mills contain a mixture of valuable and gangue or waste minerals.

Often the unwanted gangue minerals are transparent to microwave energy whereas many of the valuable metal-containing phases are microwave absorbers.

The selective and rapid heating of the receptive phases induces large thermal stresses within the rock due to differential rates of thermal expansion, and this results in micro-fractures at the grain boundaries and significantly reduces the amount of energy required to grind the rock.

Before microwave treatment

After microwave treatment



Although the current energy consumption figures for the minerals industry may still be economically acceptable, this is not likely to be the case in the very near future. The legislation-driven targets for energy and emissions reduction, and given the fact that mining companies have been forced to exploit smaller and leaner reserves mean that energy consumption will begin to make larger and more significant contributions to the company balance sheet. In this context the use of microwaves for efficient mineral processing seems to have a very bright future, but this is only the tip of the iceberg in terms of the potential application of microwave treatment in the wider process industries.

Other applications being studied at Nottingham are the use of microwave processes in thermal desorption and pyrolysis processes. The efficiency of thermal desorption processes can be greatly increased using microwaves as only the receptive phases absorb microwave energy, with little wasted on the surrounding materials. Consequently, treatment times can be significantly reduced and throughputs increased, which has been demonstrated in the treatment of oil contaminated drill cuttings from North Sea drilling operations. Microwave treatment is well suited to pyrolysis processes as inert environments are required in order that the chemical conversions are achieved at high temperatures without combustion of the feed or pyrolysis products. Achieving the high temperatures required for pyrolysis using conventional heating is relatively slow and inefficient, whereas microwaves can rapidly heat the organic materials within the pyrolysis reactor. Pyrolysis via conventional heating results in a relatively wide range of products due to the temperature variations which occur as a result of conventional heating processes. With microwave heating the reaction temperatures can be achieved very rapidly, leading to less variability in the products. In collaboration with the Nottingham Fuel & Energy Centre the current focus of microwave-induced pyrolysis work is the production of fuels from waste organic materials, particularly high-grade char rather than corrosive bio-oils which are difficult to store and transport. Production of carbon-based fuels from non-fossil sources is an area which is currently receiving a great deal of attention, with much of the focus on pyrolysis and gasification processes. In this respect microwave treatment provides a realistic commercial option for meeting future non-fossil energy demands.

The advantages of microwave processing have been seen to be much more apparent when higher power (15 kW and above) systems are used in conjunction with carefully designed cavities. For example, the energy requirements for producing rock micro-fractures were reduced from 20 to less than 0.5 kilowatt hours per tonne of rock using this approach.

One of the current and most technically-demanding challenges being undertaken by the University of Nottingham is the implementation of microwave technology on a commercial and continuous scale in the process industries. As well as focussing on large scale continuous rock fracture, attention is also being paid to the continuous treatment of oil polluted drill cuttings from North Sea drilling operations. Microwave energy is used to remove oil from the drill cuttings so that it can be recycled back into the drilling mud system and prevent the current practice of having to transport cuttings back to shore for treatment or disposal. The advantages in this case lie in the selective and rapid heating of the microwave receptors within the contaminated cuttings, with little energy expended on the surrounding rock materials. This results in very short residence times within in the microwave cavity and allows for a relatively small plant footprint, which is ideally suited to the offshore drilling environment where space is often at a premium.

One of the key issues in scaling up microwave heating equipment is the frequency which is used. Domestic microwave systems use a frequency of 2.45 GHz, which is well suited to small scale applications due to the relatively short wavelength at this frequency. Higher power industrial microwave equipment tends to operate at frequencies of 433 or 896 MHz, which translate to longer wavelengths and larger cavities. The ability of materials to absorb microwave energy, or dielectric properties, vary with the applied microwave frequency. Clearly, experiments performed at 2.45 GHz may not then give a realistic indication of the case at lower frequencies, and factor appears to have been neglected by many. In this case detailed electric field modelling is required along with detailed knowledge of the materials dielectric properties to ensure that the specifications of the cavity are suitable. In the drill cuttings case significant volumes of steam and oil vapour are evolved upon heating which can lead to the formation of arcs and plasma if the gases are allowed to accumulate. Gas sweeping and extraction requirements have formed an essential part of the design, as well as the specialist bulk solids handling equipment needed for continuous processing. Inevitably the resultant process is a compromise between the optimum design in terms of electric field distribution, gas extraction and solids handling.

One of the keys to success in this project has been the highly multi-disciplinary approach taken, with expertise in materials handling (Professor Mike Bradley and his team at the Wolfson Centre for Bulk Solids Handling, University of Greenwich), and Electromagnetic Simulation (Prof. Steven Bradshaw and his team at University of Stellenbosch, South Africa) combined with microwave processing and process engineering researchers at Nottingham to produce a high throughput (500-1000kg/h) pilot plant which is now operating successfully (see below).

Pilot Plant

The two highlighted cases of rock fracture and drill cutting treatment demonstrate that the simple microwave oven cannot give a reliable indication of the technical nor economic viability of a particular process. However, the key breakthrough in understanding is that detailed microwave heating studies are very much multidisciplinary exercises that go far beyond the realm of the chemical, mechanical, electrical or mining engineer alone. Over the past few years the research group at Nottingham has built up a network of interested parties with various areas of expertise with the aim of conducting joint research programs. With the university spearheading the chemical, minerals and mining engineering aspects of various projects, external bodies provide support in the areas of electrical & microwave engineering, electric field modelling and bulk solids handling equipment. In addition, the University is a core member of the High Power RF Faraday Partnership (HPRF) which exists to develop, and promote applications of RF and microwave energy in many areas including industrial processing. To enable as many users as possible to have access to the multi-disciplinary expertise which is required for success in industrial microwave processing, the University of Nottingham and the HPRF Faraday Partnership have established the National Centre for Industrial Microwave Processing. This centre, based at the University of Nottingham, provides a focus for the testing, development and scale up of microwave processing systems. It is open to academics and both small and large industry to investigate and test potential microwave applications from bench to pilot scale and beyond, utilising a wide range of specialist equipment without incurring excessive cost.

The potential advantages of microwave treatment in the process industries are numerous, as are the number of potential applications. However, the technology has progressed far beyond the realm of a single engineering discipline and requires a multidisciplinary approach if the advantages are to be realised commercially. Through both formal and informal networks of multi-disciplinary expertise the microwave processing team at The University of Nottingham continues to play a leading role in meeting the challenges in implementing the technology at a commercial scale.

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News

C Tech Innovation Ltd wins the Prestigious RUSHLIGHT Award

The Rushlight Awards are designed to celebrate the significant achievements of UK and Irish technology, innovation and commerce in helping to address the key issues of climate change and waste management.

C-Tech's award is for their unique WEEE *Waste Management Software Analysis Tool*, which allows an economic assessment of end of life options for electrical and electronic items (from a cost perspective) to be made. The tool analyses all types of Waste Electronic and Electrical Equipment (WEEE). The tool is based on a waste hierarchy approach and represents a powerful method of performing cost comparisons between the various options for WEEE at product end-of-life.

Ged Barlow, C-Tech's Managing Director said "We are absolutely delighted to receive this award which confirms the role we are playing in waste management technologies. It is a justifiable reward for the hard work we are putting into this area

Events

CEM 2008

7th International Conference on Computation in Electromagnetics

7-10 April 2008, Quality Hotel, Brighton, UK

The Institution of Engineering and Technology

Michael Faraday House, Six Hills Way
Stevenage, Hertfordshire,
SG1 2AY, UK

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ICMMT2008

International Conference on Microwave and Millimeter Wave Technology

April 21-24, 2008, Nanjing, China
* Paper Submission Deadline: January 20, 2008
* Acceptance Notification: February 20, 2008
* Advance Program Delivery: April 1, 2008

Details from:
http://www.icmmt2008.org/

Finite Elements Workshop

The 9th International Workshop on Finite Elements for Microwave Engineering
8 – 9 May 2008 Bonn, Germany
http://www.lte.uni-saarland.de/fem2008/

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IEEE CEFC 2008

13th Biennial Conference on Electromagnetic Field Computation

Athens May 11-15 2008
Details from:
http://www.cefc2008.gr

IMPI's 42nd Symposium

June 26-28, 2008
Chateau Sonesta, New Orleans, LA, USA
for further details visit
http://www.impi.org/Meetings/index.html

GCMEA 2008 MAJIC

1st Global Congress on Microwave Energy Applications
Otsu Prince Hotel. Lake Biwa, Otsu, Japan, August 4-8 2008
Organised by the Japan Society of Electromagnetic Wave Applications
Chairpesron Professor Nikawa Kokushikan University
Executive Committee Chairperson Prof M Sato NIFS
International Committee Chairperson B Krieger Cober Electronics USA
http://www.jemea.org./majic2008/

MEP 2008

A colloquium on Modelling for Electromagnetic Processing, Hannover Oct 27-28 2008
is organized by the Institute for Electrothermal Processes of the Leibniz University of Hannover and the University of Latvia.

Deadline for abstracts March 2008

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12th International AMPERE Conference

Microwave and High Frequency Heating, September 2009
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