AMPERE NEWSLETTER

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THE GENESIS OF A NEW GROUP AT CARTHAGENE

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In August 1998, the Government of the Region of Murcia (Spain) decided on the creation of a new School for Telecommunications Engineering within the Technical University of Carthagene, and in early February 1999 appointed me as Vice-Dean for the task of attracting young and experienced PhDs to start up research groups linked to the new School. Let me remind you that in Spain microwave engineering is mainly taught at the Telecommunication Schools. There is no doubt that being parachuted into such a task concentrates the mind. Thus, I have brought along 5 microwave-related researchers among some other specialists through inter-university agreements with Valencia, Madrid and Lausanne, and the seed of a new group, named Electromagnetism and Microwave Engineering Research Group (GIMRE) was planted. Industrial applications of microwave and RF heating was placed among the teaching subjects at both Dipl.-Ing. and Ph.D programmes. A picture of GIMRE members by one of the University's ancient cloisters is shown below.

David, front row third from the left, with members of the new GIMRE group at the Technical University of Carthagene (Spain)

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Editor's Comment

I am delighted that David Sánchez-Hernández from the Electromagnetism and Microwave Engineering Research Group (GIMRE) at the Technical University of Carthagene in Spain has accepted my invitation to describe his activities culminating in the formation of a new School of Telecommunications which now forms part of the Technical University at Carthagene. David left the group in Valencia headed by Professor Elias de los Reyes in 1998 when he was invited to set up the new school at Carthagene. I am pleased to see that within the new school research in microwaves plays a prominent part.

This issue contains another article from Spain written by Nico van Dijk who heads Design Andalucia s.l., a company promoting the use of rf and microwaves for various applications. Nico describes a dryer for RF applications using a novel waveguide arrangement which appears on page 3. Many thanks to Nico for sending me this article.

The second report from John Bows on another CASE STUDY appears on page 5. I am extremely grateful to John for putting these industrial case studies together as I am sure they serve to remind us that the cost involved in setting up a new system is as important as getting the technology right in the first place.

As we have described in the previous issue, the AMPERE Data Bank and Subscriptions has moved to Loughborough University where indeed the 9th in the series of AMPERE conferences will be held in September 2003. The conference website will be accessible from early January where full details on the conference can be found. Finally, I am now based at St John's where my details are:
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e-mail: acm33@cam.ac.uk

Ricky Metaxas
St John's College, University of Cambridge

After 3 years the team is now well established and has a large number of on-going projects with well-equipped facilities, currently recognised as a group of excellence by the Spanish National R&D Evaluating Agency (ANEP) and with an excellent national reputation. A web page is under preparation and permanent researchers include four Readers in Microwave Engineering and 9 Dipl.-Ing. Lecturers, with over 15 PhD students and research fellows and myself holding the Chair of Vice-Chancellor of Innovation and Technology Transfer at the University. Retaining the excellent cooperation with the microwave heating group in Valencia, five main research lines have been developed at GIMRE: microwave heating, electromagnetic scattering and dosimetry, microwave waveguide element, radio-electric coverage and military research.

Microwave Heating Research

The first line is headed by Dr. Díaz-Morcillo, and five important projects are currently under way in the group at present. The use of microwave energy as an alternative for conventional pesticides in disinfecting processes of soil and food products is being investigated with joint private and public funding by the European Regional Development Fund (ERDF) and the Spanish Ministry of Science and Technology National Research Programme.

The patent-protected rice disinfecting microwave unit at work at the funding company

Likewise, private funding is allowing research on leather drying using microwaves at Carthagene, and two prototypes have been built with microwaves assisted by hot air. More recently, a privately-funded project on modelling of combined microwave/hot air drying for construction materials has started in cooperation with the Technical University of Valencia. Another project funded by the Spanish National Research Programme is related to the design of multimode multifed auto-matching structures used in industrial microwave systems by means of experimental validation of simulated results. Preliminary results that lead to the financial support were presented at the Ampere conference in Bayreuth.

Electromagnetic Scattering and Dosimetry

In this line of research, headed by myself, we intend to minimise SAR values, which is an indication of the speed at which the human body absorbs EM energy. In 2001 I obtained a seat on the Spanish National Board for Radioelectric Emissions, sharing decision-taking procedures with eight other appointed experts. Previously, the group had published the first Spanish report on mobile dosimetry, and developed and patented novel antenna structures that reduce radioelectric emissions. The good reputation at national level of GIMRE in this research area persuaded the Ministry of Science and Technology, through *Colegio Oficial de Ingenieros de Telecomunicación*, to appoint GIMRE to develop the Spanish protocol for measuring radioelectric emissions from mobile communications towers. The Protocol was also delivered to the European Commission through the Joint Research Centre at Ispra (Italy) and to CENELEC, and it is currently the basis for a European consensus on a common Protocol. A summary of this Protocol has been accepted for publication at the IEE Proceedings on Microwaves, Antennas & Propagation.

GIMRE is a full member of AENOR (Spanish Normalization Agency) on several committees, and has been appointed official Spanish representative at CENELEC TC106X Committee (Electromagnetic Fields in the Human Environment). Moreover, when four children were diagnosed as having leukaemia in Valladolid in a school very close to a radiocommunications site, the Commission of Independent Experts, funded by the Spanish Ministry of Health and by the Regional Government of Castilla-y-León, selected GIMRE within all research groups in Spain to properly evaluate the emissions at and around the school. A final report and some GIMRE answers to health experts' questions can be found at http://www.jcyl.es/garciaquintana. The report is being incorporated in the EMF and health related research performed by COST-281. With funding from the Spanish Ministry of Science and Technology, GIMRE is developing new methods for reducing Specific Absorption Rate values in mobile units, as well as minimising radioelectric emissions from mobile communications base stations.

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CONSTANT VOLTAGE R.F. WAVEGUIDE DRYER

by Nico van Dijk
High Frequency Design Andalucia s.l. Spain

Nico van Dijk

Large scale R.F. processing (drying, thawing, melting, and heating) for industrial processing raises the need for high power low cost installations. Especially processes like the drying of harvested materials (rice, cereals, 300 tons a day) and the recycling of asphalt and the drying of municipal sludge, require power levels up to and beyond 1 MW and deep penetration. Therefore, a Radio Frequency system at 27 MHz has been designed. A major problem for this kind of installations is the tuning of the applicator. Variable capacitors that can be used at power levels up to 100 kW often have to be designed and constructed. Beyond these power levels, automatic tuning becomes a problem. In addition to that, the transport of high frequency energy to a load with an impedance not matched to the cable impedance, results in standing waves and very high voltages and currents in filters, tuner capacitors and inductors. These systems are difficult to construct for high power and as a consequence, are expensive.

The automatic tuned systems prevent a long term impedance mismatch, but applicator voltages rise often to unacceptable levels for applicators which are not properly matched. The above problems limit many applications in an economic sense.

In order to avoid the above problems and to decrease substantially the price per installed kilowatt a waveguide based R.F. system has been designed. This system combines the applicator with the generator in such a manner, that no impedance transformations (that give rise to high voltages or currents), can arise. The applicator has a constant RF voltage and does not need any load tuning. As a result, the system does only comprise of the generator parts and an aluminium box. Even the anode choke can be omitted. In addition to that, the system is inherently well shielded. It can be used both for batch processing and feed-through processing.

The applicator is also the resonator (tank circuit) of the generator and has the shape of a single ridged waveguide of half a wavelength. The applicator is the space between the upper side of the ridge and the ceiling of the waveguide.Because the wavelength in the waveguide is larger than that in free space, the applicator area can be larger than other systems offer. Another advantage is that the applicator plates are all connected to the structure and the voltage between the plates rises gradually with the position in the applicator, avoiding abrupt increases that can give rise to non-uniform power distributions and arcing. Due to the constant voltage, the dissipated power density is constant (assuming uniform conductivity) and not dependent upon the applicator load. The applicator can be loaded from zero to maximum without any problem. Because the system does not need any load tuning and all these materials are omitted, and because dangerous impedance transformations do not occur, power levels can be increased beyond 1 megawatt.

In order to prove the theory, the University of Malaga wrote a program to calculate the field distributions in the waveguide and the load impedance of the power tube. Using this program, a worst-case frequency- and power scaled model has been designed and constructed. The generator tube was an Eimac 3CX3000A7 connected in grounded grid and for practical reasons the laboratory tests were performed at a match higher frequency, around 145 MHz. The trials were very successful from the beginning with the generator giving 4 kW in the load with an efficiency (DC anode input to load) of about 69 %.

Tests were performed to dry raw cotton, thaw frozen materials and to heat various materials. No adverse effects were found when the applicator was unloaded. An engineering test with a very simple closed loop frequency stabilisation circuit was able to keep the frequency within +/- 100 kHz from no-load to a fully loaded applicator when drying wet cotton.

It is envisaged that the full size model will be used to thaw 50 tons of frozen butter each day using 300 kW and to dry municipal sludge using 1 MW.

For more details you can contact High Frequency Design Andalucia s.l. using the following details:
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Email: hfda@vnet.es

The Genesis of a New Group at Carthagene

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With private funding, GIMRE has up to now coordinated the correct evaluation of over 1200 GSM-DCS base stations in Spain, and predicted emission values of several new UMTS sites.

Microwave Waveguide Element Research

Within this research line, headed by Dr. Álvarez-Melcón, our main efforts have been aimed to develop a software tool for designing band-pass and band-stop filters employed in satellite communications and for input and output ports of microwave heating applicators. With funding from the European Space Agency and in cooperation with the University of Valencia, we are designing an orthomode transducer, and it is also our intention to apply such new and efficient hybrid techniques to the analysis and design of directional couplers, consisting of rectangular waveguides coupled by rectangular or circular holes, for many diverse applications. With funding by the PROFIT Spanish Programme, numerical characterization of arbitrarily shaped dielectrics for the analysis and design of circuits and antennas used in space communications is also being investigated. Likewise, the Spanish National Research Programme is funding a project on advanced techniques for the analysis and design of printed microwave components.

Radioelectric Coverage Research

The proper planning of any radiocommunication system requires the utilisation of software tools which have to work with large amounts of information (graphic environment, equipments, sites, etc.), as is well-known by Dr. Juan-Llácer, who leads this research line. In new systems (UMTS, LMDS, etc.), however, more accurate models are needed, because these systems deploy most of their base stations in macro-cellular and micro-cellular urban environments where different propagation mechanisms apart from free space, diffraction or reflection (typical in rural environment) exist. With the aid of an in-house developed software funded by the Region of Civil Protection Office, all digital TETRA stations at the Region of Murcia have been allocated by GIMRE.

GIMRE EMF evaluating unit at Valladolid, which created a huge national press impact, and the site under inspection

Military Research

Notwithstanding the need for confidential protection over the two military-related research projects under way at Carthagene with financial support by military companies and the Spanish Ministry of Defence, we can safely state that one of them is related to the use of novel multiplanar material for reduced dichroic RCS in conformed-to-NATO standard warships while the other is minimising electromagnetic interference within a real warship environment. It is worth mentioning here that Carthagene holds the command brain of the Spanish Navy at the Mediterranean Sea and that the biggest Spanish warship and solo submarine factory is located in the bay of Carthagene.

Summary

A considerable effort has been made, and still continues, to create and organise a new Engineering School at Carthagene under the auspices of GIMRE. Given the 'size of the canvas', there is still much to be done at GIMRE. Yet, within the creation stage, top-quality research has also been the target, and it is our aim to become part of the ever increasing AMPERE community with original contributions at the biennial conference. It is up to our research colleagues to judge the value of our R&D effort in the near future, but with over 10 journal publications a year and 10 on-going yearly projects, GIMRE is now reaching maturity at the Technical University of Carthagene, and 2003 may be a year for gaining international reputation.

See you all at Loughborough.

David Sánchez-Hernández

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Case Study

No 2: Microwave pre-heating epoxy resin saves $865,000 per year

During 2001, a major multinational chemical company in the Midwest (US) doubled production rates and made many processing savings in their resin heating line by using a 915 MHz cylindrical microwave heating system to pre-heat the resin.

The challenge was to pre-heat epoxy resin from 50 to 180°C prior to extrusion while maintaining a final product specification within acceptable quality ranges. Difficulties of conventional heating through a tubular heat exchanger include low volume throughput, high volumes of catalyst and wide ranging variation in final product quality. Also, frequent shut down of the production line due to solidification of the epoxy in the heat exchanger resulting from the lack of temperature control was a problem, as well as high maintenance costs resulting from the need to clean 61m of heat exchanger.

The solution was provided by Industrial Microwave Systems (IMS), who took 9 months from original R & D trials to the supply of commercial equipment. Installation and commissioning took less than 30 days. Operator training in use of the generator and control systems was accomplished in less than one week.

The installation comprises a 100 kW, 915 MHz Cylindrical Heating System. Figure 1 shows an equivalent system. The 130°C change in temperature was achieved in less than two seconds through a microwave exposure region of less than one metre resulting in an ideal, consistent final product quality.

Figure 1

The system uses a two stage elliptical heating applicator, shown in figure 2. Each applicator has a heating length of 30 cm, overall height of 61 cm and a diameter of 25 x 41 cm in the elliptical dimension. With interconnecting pipe work and wave guides, the overall height was 3 metres. The unit it replaced was a 61 m long, 5 cm diameter tubular heat exchanger with a steam heating jacket.

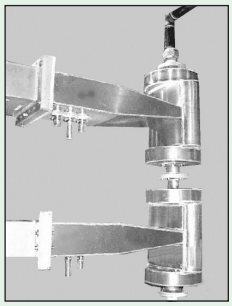

Figure 2

Process benefits were a doubling of throughput volumes, a four-fold reduction of production line shut-downs, and a ten-fold reduction in maintenance costs. The line achieved 98% absorption efficiency of the microwave energy generated and a total system efficiency of 83%. Uniform, volumetric microwave heating also eliminated clogging and the associated shut downs and maintenance.

The total annual value of the microwave heater is $865,200, based on the following value proposition:

1. Value of Throughput Increases. Additional capacity of 230 kg / hour generated 1360 tonnes additional product per year, worth $750,000 of Incremental Contribution Margin generated by the microwave heater alone.

2. Value of Catalyst Reduction. Normal operating mode catalyst consumption was 0.8 kg/hour. Catalyst consumption when employing the microwave heater was reduced to 0.6 kg/hour. Annual savings at 100% production capacity, at a catalyst cost of $11 / kg, are $57,600. As the microwave heater doubled production throughput, the annual saving doubled to $115,200.

The microwave power required to heat 550 kg / hour of resin is 42 kW of absorbed power. Allowing for microwave conversion and absorption efficiencies, the actual power required for this duty was 53 kW. Operating 24 hours/day for 50 weeks, 7 days a week and at an electricity

Case Study

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cost of 4.5 cents/kWh, the total power cost is $20,034. The maintenance cost is $1 per kWhr per magnetron or $8,400 so the total annual operating cost is $28,434.

Even if the steam heated tubular unit heating cost was $10,000 per year, the annual downtime, loss of production due to change out of the exchanger and labour and materials involved in jack hammering the tubes plugged with solid resin cost at least $100,000. Add to that the savings in catalyst, and the increased production as stated earlier, then the savings become even more significant.

The installed and commissioned capital cost of the microwave heating and control system was around US$ 250,000. As a comparison, the shell and tube unit without steam boilers, installed steam train and control system was about $100,000. So the payback on the capital investment was less than 3 months.

A company spokesman said of the installation: "After the microwave heater replaced the steam heated tubular unit, production rate doubled, downtime due to fouling was virtually eliminated and there were savings resulting from less use of catalyst in our formulation."

IMS's approach on successful applications of microwave heating is to focus on applications where the customer has a clear economic advantage in changing to microwave technology, and only invest efforts where the unique benefits of IMS's ability to create a uniform field of microwave energy are of benefit to the customer. Further details can be found on http://www.industrialmicrowave.com and thanks are due to David Parrott for supplying details for this case study.

John Bows, Unilever Research Colworth, UK

NEWS & EVENTS

9th AMPERE International Conference on Microwave & HF Heating, Sept 2003, University of Loughborough
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Jon Binner and his team has just created the following website: http://www.lboro.ac.uk/departments/iptme/Ampere9/Index.html
which has many of the details relating to the conference. There is also a dedicated conference email address ampere9@lboro.ac.uk which is especially intended for handling any enquiries you might have. Anyone interested in exhibiting at the conference should contact the Loughborough team as soon as possible with respect to costs.

A CEM organised conference on Microwaves in Chemistry will be presented in association with the 4th Annual Florida Heterocyclic Conference, which will take place March 10-12, 2003 at the University of Florida in Gainesville.
The details are:
7-9 March, 2003, Gainesville, FL(USA) "1st International Microwaves in Chemistry Conference", Headquarters, CEM Corporation, PO Box 200, Matthews, NC 28106, USA
Tel: +(800)-726-331, Fax: +(704)-821-7015,
email: Doug.Ferguson@cem.com
website: http://www.cemsynthesis.com/html/mic_conf.htm

Correction to case study article in issue 34 on page 5, immediately after Figure 2 it should have read (missing text highlighted in red):

"To achieve an even heat distribution in the production unit, the applicator consisted of a multimode cavity with 6 coupling port applying microwave energy. Constant energy input zones were designed to avoid over-exposure (the 6 coupling ports can be switched in way that a 10kg or 200kg barrel can be heated rapidly and uniformly). Product-specific temperatures programmes were developed. On-line infrared cameras were installed to monitor the pack wall temperature as a process control measure."

Profuse apologies to John Bows from the Editor.

AMPERE Subscription Rates

Europe:	1 year	£30.00
	2 years	£50.00
Worldwide:	1 year	£35.00
	2 years	£60.00

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Your news and views are always welcome

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