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EDITORIAL

I am pleased to present in this issue a contribution from Prof. Georgios Stefanidis and Dr. Guido Sturm from Process and Energy Department at Delft University of Technology, about a microwave plasma system to extract energy from human wastes. The described system is capable of generating more energy than the one employed at the microwave system and therefore is a self-sustained process.

Mr. Fernando Meggiolaro responsible of Stalam's sales area describes a study where it is proven that RF systems are a real alternative to the conventional pasteurisation and sterilization processes for fruit preparations and other intermediate and finished food products.

The Afterthought piece in this issue, written as usual by Prof. A. C. Metaxas, shows how the Raspberry Pi, a very low-cost computer board, has been used to completely change the user experience with the microwave oven providing connection to the Internet and advanced features.

I take this opportunity to wish you all the best during the next summer months and to invite you to 15th AMPERE conference to be held in Krakow University of Technology (Poland) during 14th-17th September, 2015.

Editor
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MICROWAVE PLASMA GASIFICATION OF HUMAN WASTE MATERIALS

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Introduction

Approximately 2.6 billion people on earth currently lack access to safe and affordable sanitation. The negative health impact of poor sanitation is enormous. To change this situation the toilet has to be reinvented. The Bill & Melinda Gates Foundation have posed a challenge to researchers worldwide to develop toilet solutions that do not require water, energy, or sewage infrastructure, and are affordable for people in developing countries.

The TU Delft approach is to employ a small-scale processing facility that gasifies the biomass in a microwave generated plasma. By applying energy in this form, lower residence times are required and heat losses can be compensated for, so that processing facilities can be scaled down considerably, enabling decentralized treatment. The gasification step is preceded by a pre-treatment stage to create optimal feed quality. In order to create a self-sustained process, the produced syngas is fed to a gas cleaning unit and then to a solid oxide fuel cell (SOFC) to recover the energy expended for microwave field generation.

This project was funded by the Gates Foundation with the objective to build a small scale demonstration plant for human waste materials treatment and energy recovery in a fuel cell. The miniplant in currently nearing completion and initial tests have demonstrated the feasibility of continuous flow operation of a combined microwave plasma gasification system (figure below), gas cleaning unit, and solid oxide fuel cell system.

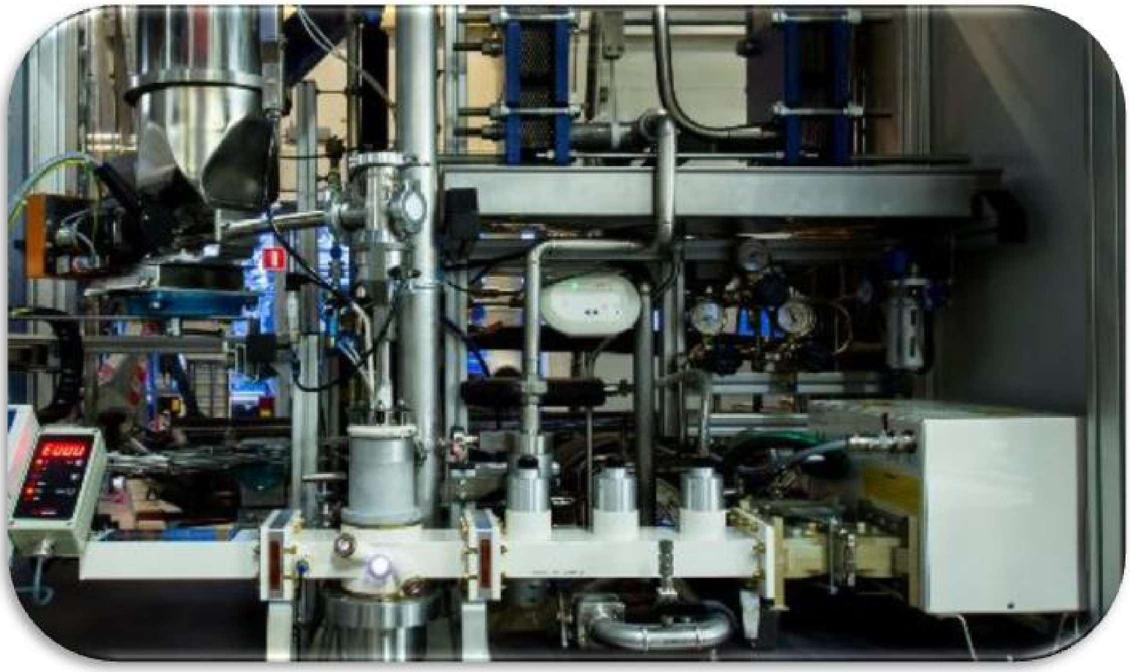

Figure 1: Microwave plasma gasification system.

Plasma advantages

Very intense processing conditions can be reached under plasma. High temperatures and the occurrence of highly reactive radicals accelerate the destruction of waste materials, converting them into syngas. Syngas is a fuel gas consisting of a mixture of hydrogen and carbon monoxide. This gas can be used as a raw material in chemical processing or as a fuel for energy generation. The main advantages of plasma gasification over other gasification technologies are the following:

1. It is robust with respect to variations of feedstock composition and (in)homogeneity. It is particularly tailored for processes where the feed composition is ill-defined or even unknown, which is fitting to the context of consumer level waste treatment. Since an external electromagnetic energy source drives the process, any amount of energy may be applied to raise the temperature to a sufficient level for the pyrolysis of any waste material to convert it into useful syngas.

2. Since the thermal energy is generated both via dissipation of a microwave field and via partial oxidation of the feed material, the process can operate at reduced oxidizer (plasma agent) flow rates compared to more conventional thermal gasification processes. Therefore, the product gas is less diluted (or is more energy dense), which implies reduced equipment volume downstream (gas cleaning, SOFC units).

3. Because the heat does not necessarily need to come from oxidation, there is flexibility as regards to the choice of the plasma agent; it can be nitrogen, air,

steam or any mixture thereof. This is an additional degree of freedom to the process design that may be used to reduce CO_2 emissions.

Performance and efficiency

The gasification process was investigated with a series of short duration, continuous flow experiments. Biomass was fed into the plasma zone of the reactor where it was converted into fuel gas. Table 1 presents some of the results obtained. It can be seen that the energy contained in the product gas can exceed considerably the microwave energy expended in the reactor.

The best result showed an energy recovery of 184% at a feedstock conversion of ~20%. This indicates that 1) a self-sustained process is feasible, and 2) that a tailored reactor design that enables full conversion of the feedstock will improve the energy recovery even further. A new design is currently under development.

Table 1. Product and energy yield for several process conditions

Forward microwave power Plasma agent	4 kW N_2 , 20 l/min	4 kW Air, 20 l/min	4 kW Air, 15 l/min
Product gas composition			
H_2	13.6 %	15.3 %	23.3 %
CO	16.6 %	24.8 %	34.5 %
CO_2	0.3 %	7.0 %	4.4 %
CH_4	0.1 %	1.0 %	1.0 %
Energy recovery – product lower heating value vs. net microwave power	99 %	151 %	184 %

The CH_4 levels that were obtained are low compared to thermal gasification. This indicates relatively low tar formation because CH_4 results from tar cracking. Tar formation is a major problem for gasification in general and it appears that plasma gasification is less sensitive to this problem.

Future work

Regarding plasma gasification the objectives for future are twofold. On the one hand it will be used for understanding and optimization of waste treatment processes under plasma conditions. Because a household does not generate human waste only, other waste types also get consideration. On the other hand, the plasma unit will be used as a test bed for development of novel reactor concepts. Further, the research into integrating plasma gasification with fuel cells for energy recovery will continue to develop it into a solution that converts waste materials into a useful source of energy

IN-LINE PASTEURISATION OF FLUIDIZED PRODUCTS BY MEANS OF RADIO FREQUENCY HEATING

by Ferdinando Meggiolaro

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Volumetric heating

For many years the main alternatives to the conventional heating processes have been the volumetric heating technologies, such as Radio Frequency, microwaves, ohmic heating.

All these systems have proved to be very effective when applied to the pasteurisation processes, in terms of microbial inactivation, but as far as the homogeneity precise control of the temperatures is concerned, the Radio Frequency has provided the best results.

Stalam technology

Since late 90's, STALAM has developed the first prototype for the continuous pasteurisation of liquids and fruit preparations. The product is pumped inside Teflon pipes and then heated up when it passes through the electromagnetic field generated between two facing metallic plates. The product is uniformly and quickly heated at the rate of 1°C/sec.

While this first prototype was developed as an alternative heating technology on the fruit for quicker, more uniform and efficient results, on the second RF production installation, we decided to study closely the RF effect on the complete inactivation process.

With the aim of making a thorough analysis on the sterilisation of fruit preparations, baby food, milk and by-products, the new unit was designed with a higher RF output capacity of 75 kW, delivering up to 2500 Kg/h of treated product. DN 65 pipes (2"1/2) were used, and product cooling was done through a tubular type cooler.

The product

The following is a typical recipe of a strawberry fruit preparation:

- fresh strawberry pieces 18-25 mm;
- sugar 30 - 45%;
- thickening: starch and pectin;
- Bostwick: 7-9 at 60°C;
- Bostwick: 10-12 at 100°C;
- Bostwick: 6-7 at 30°C;
- pH 3.5 – 4;
- Bx: 35 – 55.

It is commonly known that the strawberry is very sensitive to heat exposure; the degradation of the fruit above 100°C is almost complete, resulting in a loss of mass consistency, colour and flavour.

From the microbial point of view, the typical profile of the preparation may be the following:

- Mesophylic aerobial load at 32°C 5000 u.f.c./g. after RF treatment < 10
- Sporogenic mesophylic bacterial load: Initially > 200 u.f.c./g. and after RF treatment < 10
- Hyphomycetes: Initially > 1000 u.f.c./g. and after RF treatment <10
- Yeast: Initially > 1000 u.f.c./g. and after RF treatment < 10

The main goals

Firstly, there is a clear need for a reliable pasteurisation process, able to improve the product's shelf life. Secondly, equal importance is given to the quality characteristics of the product by respecting the natural characteristics of the fruit (colour, flavour), its original texture, and the nutritional value it provides.

Thirdly, an important amount of data has demonstrated the benefits achievable in the industrial aspects of the process such as operating costs, productivity, flexibility of the plant, maintenance costs, working environment.

The plant

Designed and manufactured with the best components available on the market specifically for the pumping and the cooling stages, the plant combines the most accurate solutions already known with the innovative application of RF field. The use of RF heating method has also permitted the introduction of many innovative systems to the processing plant, otherwise difficult to implement in the old system.

The main stages of the process consist of:

- Cleaning in place (CIP) and sterilisation cycles;
- the stand-by phase;
- the product processing;
- the PIGGING system for the in-line change of product, and the emptying of the plant without product losses.

The complete automation and control of the plant allows the operator to add some ingredients to the main recipe parameters in line for each different product or processing phase.

The only energy and utilities supplies required are:

- electricity
- compressed air
- water

The total installed electrical power is approximately 200 kW. The compressed air required is minimal. The maximum water consumption is approximately 20 m^3/h.

The process

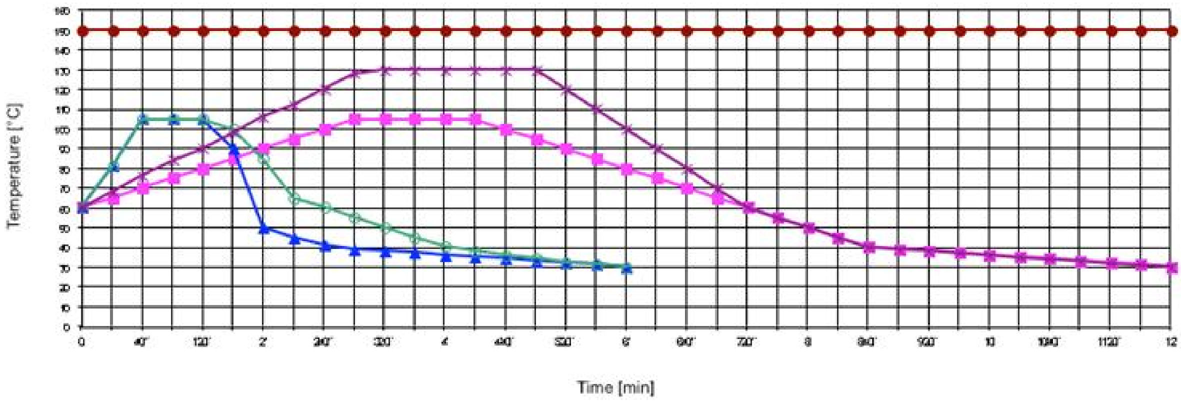
It is known that the volumetric mass heating of a material depends at least on three factors: the dielectric constant ε, the electrical conductivity K (both factors are dependent on the temperature) and the frequency of the electrical field f for a constant electric field magnitude. The dipolar molecules vibration, and the movement of the free charges (dissociated ions) inside the material, are the two main processes of heat generation inside the product at RF frequencies.

The mixed preparation arrives to the buffer feeding vessel at a temperature of 60°C. After a short pipeline, the product is pumped into the RF unit, from which it exits at the pasteurisation temperature of 98°C. The temperature set-point is controlled and maintained at a tolerance of ±0.5°C. The heating time is a few seconds, and the temperature obtained inside the product is very uniform.

After the RF pasteurisation stage, the product immediately reaches the cooling section, where its temperature is brought down to the required level (20°C to 30°C) suitable for aseptic filling. The flow rate is approximately 2000 Kg/h.

In Fig. 1 the thermal profiles of the process are shown, compared to the conventional ones. In Fig. 2 also the curves of viable microorganisms reduction are compared.

The large reduction of the process time is related to the volumetric heating, which achieves a uniform, fast and simultaneous temperature rise within the fluid and the solid particles.



pos. 1: temperature profile of the heating fluid (steam) in a conventional process
pos. 2: temperature of the product in contact with the surface of the tube, obtained with the conventional process (steam)
pos. 3: average temperature of the product inside the tube, obtained with the conventional process
pos. 4: temperature of the product inside the tube, obtained with the RF treatment
pos. 5: temperature of the product in contact with the surface of the tube, obtained in the RF treatment

Figure 1. Comparison of the temperature profiles between the conventional and the RF method, at a processing temperature of 105°C

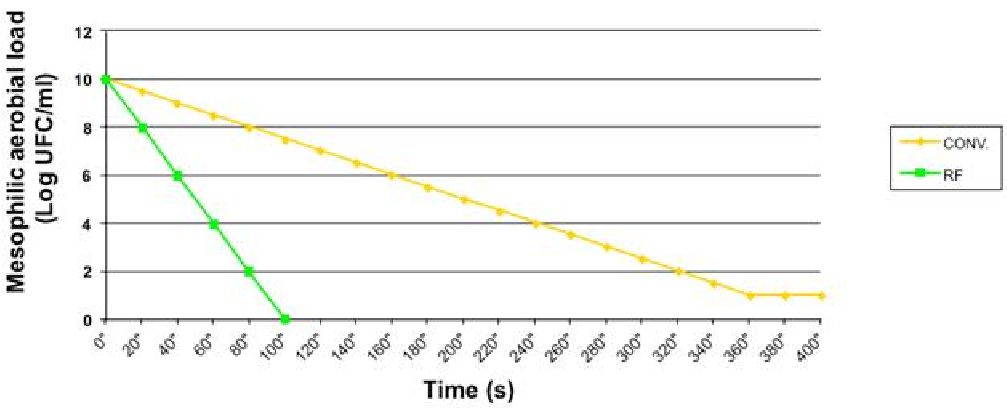


Figure 2. Comparison between a typical inactivation curve with the conventional plant and the one obtained with the RF/L unit at same target temperature

The fact that the required microbial population decay was reached without a temperature “hold” section, shows that the RF electrical field has an additional direct “killing” effect on the micro-organisms other than the thermal shock. Through continuous tests and results analysis, we have been able to gradually reduce the processing temperatures, without loosing the levels of desired inactivation, which would only be obtained at higher temperatures in a conventional system.

Additionally to these results, an obvious improvement to the quality of the product has been noticed. It was clearly shown, that at the end of the RF process, when compared to a conventional treatment, there is a better fruit consistency, an improved flavour, no colour changes, and a minimum loss of fruit pieces.

Safety

The use of Radio Frequency equipment does not introduce any health risk to the operator. Thanks to an accurate enclosure design, enabling the perfect sealing and containment the RF field inside the heat treatment chamber, the electromagnetic emissions are well below safety limits at all time. The level of electromagnetic emissions in fact, according to the European regulations in place, are lower than those generated by common electronic devices and household equipment. The whole installation is designed in line with the European standards and directives, and is provided with CE mark.

Conclusions

It is therefore evident that the RF technology represents, today, a real alternative to the conventional pasteurisation and sterilization processes, for fruit preparations and many other intermediate and finished products contaminated by thermoresistant or acidotolerant species or thermosensitive products characterized by difficult handling and heat transmission. This is mainly due to its high productivity and reliability, the great flexibility of use, and to the good quality preservation of the products.

To summarize the advantages provided by the RF technology in this specific project:

- Fast heating rate (1°C/sec);
- Reduced process time;
- Reduced use of thickenings;
- Reduced use of added colours and flavours;
- The loss of fruit pieces is almost eliminated;
- Reduced sterilization/pasteurisation temperature and time combinations;
- In-line change of product;
- Reduced maintenance costs;
- Standard Cleaning In Place protocols;
- High-energy efficiency.

AMPERE MC MEETS AT KRAKOW

The Ampere Management Committee met at Krakow (Poland) in order to discuss the organisation of the next AMPERE conference that will be held in this city during 2015. Local organizers headed by Prof. Dariuz Bogdal and the MC discussed several points regarding this event in order to improve, if possible, past AMPERE conferences.

The 15th AMPERE conference will be held during 14th-17th of September, 2015 and announcements regarding this upcomming event will be advertized both at the AMPERE website and subsequent issues of the AMPERE newsletter. Figure 1 shows a photograph of MC at the Rectoral Room of the Krakow University of Technology.

Figure 1. The Ampere MC meeting at Krakow (photograph by Juan Monzó-Cabrera)

NEWS AND EVENTS

STALAM and RF Biocidics partnership

In March 2014 Stalam and RF Biocidics have announced a strategic partnership whereby Stalam, the Italian manufacturer of high power RF industrial equipment, will manufacture Biocidics' Apex product lines. This series of equipment focuses on achieving consistent reliable pathogen control, high throughput efficiency, and cost effective performance without the use of chemicals or the limitations of external steam treatment or conductive heating. Rf Biocidics is a safety food company that provides environmentally friendly and chemical free pasteurisation and disinfestation for foodstuffs and other commodities. Biocidics is a subsidiary of Allied Minds a Boston USA technology company. For more information read the following link:

http://www.rfbiocidics.com/rf-biocidics-stalam-strategic-partnership/

35th PIERS 2014

Progress In Electromagnetics Research Symposium

Guangzhou, China, 25-28 August, 2014

Progress in Electromagnetics Research Symposium (PIERS) is an international forum for reporting progress and recent advances in the field of electromagnetic theory and its applications. Topics include radiation, propagation, diffraction, scattering, guidance, resonance, power, energy and force issues, and all other modern developments, with spectra ranging from statics to RF, microwave, photonics, and beyond.

For more information please visit:

http://piers.org/piers2014Guangzhou/

or contact:

tpc@piers.org

MEP 2014

7th International Colloquium on "Modelling for Electromagnetic Processing"

Hannover, September 16 - 19, 2014.

Papers on the following topics are welcome: Numerical and physical modelling for electromagnetic processing of new and high quality material, crystal growing of semi-conductive material, dielectric heating of non-conductive materials, production processes for new and innovative products, energy efficiency and sustainability of industrial processes.

For more information please browse:

http://www.mep2014.uni-hannover.de/mep2014.html

Or contact: mep2014@etp.uni-hannover.de

RUSTUM ROY SYMPOSIUM* AT *MATERIALS SCIENCE & TECHNOLOGY CONFERENCE AND EXHIBITION (MS&T14)

12-16 October 2014, David L. Lawrence Convention Center,

Pittsburgh, PA, USA.

This symposium focuses on the discovery of novel processing methods, manufacturing, and performance of materials systems under the influence of microwaves, electric and magnetic fields (ac or dc), laser, ultrasound and mechanical energy. The symposium explores the fundamental science and mechanisms underlying these processing methods.

For more information please browse:

http://www.matscitech.org/

or

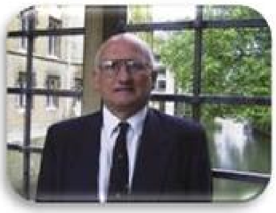
http://www.programmaster.org/PM/PM.nsf/UpcomingSymposia/03FC7215179C7A4C85257B78002D0B24?OpenDocument&ParentUNID=5E906689DEA330B085257A8E0081D4AD

AMPERE 2015
15th International Conference on Microwave and High Frequency Heating
Cracow, September 14 - 17, 2015.

The 15th International AMPERE conference on Microwave and High Frequency Heating will be staged at Krakow University of Technology, which is based at Krakow, Poland.

The conference will be held during 14-17 September 2015. As with previous conferences in the series the first day will be dedicated to staging short course(s). Details will be published online in due course at www.ampereeurope.org

AN AFTERTHOUGHT : RASPBERRY PI DRIVES A MICROWAVE OVEN



A. C. Metaxas
AC Metaxas and Associates
Cambridge, UK

The Raspberry Pi shown below was conceived by the Raspberry Pi Foundation in Caldecote, near Cambridge, UK and supported by the Cambridge University Computer Laboratory, to enable school children to master the art of computer programming. It is a very low cost computer board the size no more than a normal credit card. It's also a capable little PC which can be used for handling spreadsheets, word-processing, it even plays high-definition video or one can use it as a small server.

By October 2013, 1.75 million units have been sold word wide. Recently Electronics weekly reported a fascinating idea that a web applications developer from New Zealand, Nathan Broadbent, conceived to enable the Raspberry Pi to drive a microwave oven.

Here's a summary of the features that Nathan added to his microwave oven:

- Re-designed the touchpad
- Nicer sounds
- Clock is automatically updated from the internet
- Can be controlled with voice commands
- Can use a barcode scanner to look up cooking instructions from an online database
- There weren't any online microwave cooking databases around, so he made one: http://microwavecookingdb.com
- etc

Read all about it in the following link featuring Nathan Broadbent's idea: http://madebynathan.com/2013/07/10/raspberry-pi-powered-microwave/

Read more about the Raspberry Pi project here:

http://www.cl.cam.ac.uk/projects/raspberrypi/

Figure 1. Raspberry Pi Board

The information contained in this Newsletter is given for the benefit of AMPERE members

All contributions are believed to be correct at the time of printing and AMPERE accepts no responsibility for any damage or liability that may result from information contained in this publication

Readers are therefore advised to consult experts before acting on any information contained in this Newsletter

Association of Microwave Power in Europe for Research and Education (AMPERE Europe)