PyNE Pyrolysis Network for Europe
http://www.ceac.aston.ac.uk/PyNE/ ISSUE 3 MARCH 1997

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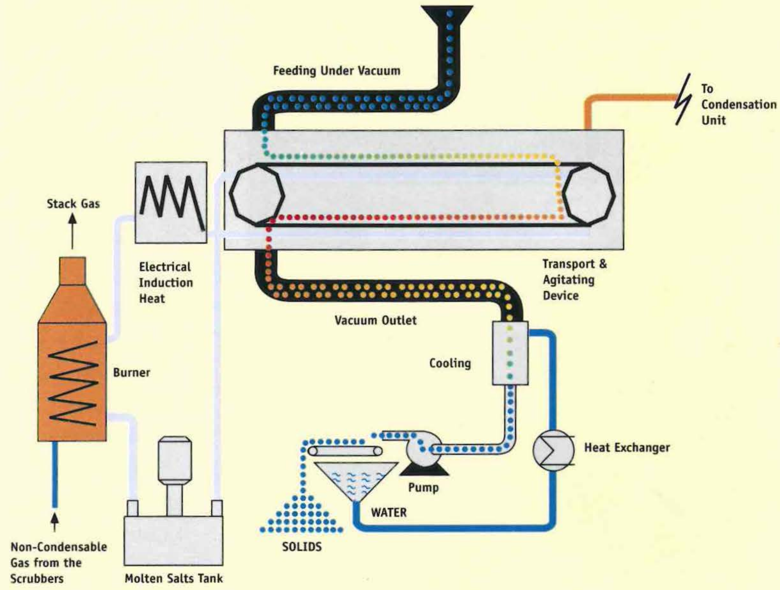
PYROVAC INSTITUTE

LAUNCHES A NEW REACTOR ENHANCING HEAT TRANSFER EFFICIENCY...

Pyrovac Institute, a private research centre and subsidiary of Pyrovac Group, is proud to announce the development of a new reactor to address the heat transfer limitations usually encountered in vacuum pyrolysis technology. This new heat transfer equipment dramatically increases the heat transfer between the reactor and the pyrolysed material.

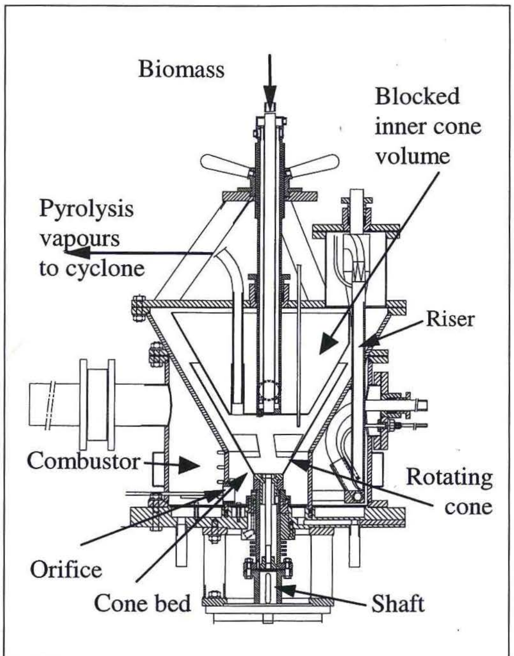
The Pyrocycling™ process from PYROVAC



continued on page 5

The latest fast pyrolysis reactor...

See page 20 for details.



Bio-oil Analysis & Characterisation

A comprehensive annotated bibliography relating to the chemical and physical analysis of bio-oils and the upgrading products from bio-oil has been compiled by Jesus Arauzo of University of Zaragoza, Spain and is available on the Internet.

Further details can be found on page 19.

Energy costs & prices in Europe.

For full details of up-to-date Energy prices in Europe complied by Wolfgang Baldauf, Germany, please see page 12

Contents

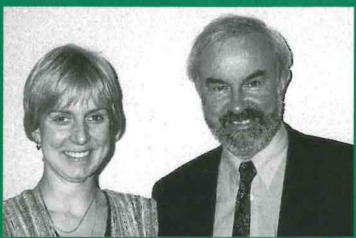
ASTON UNIVERSITY

Comments and contributions are most welcome on any aspect of the contents. Please contact your country representative for further details or send material to Claire Humphreys.

Editorial

This is the 3rd issue of the newsletter and we would like to thank everyone who has contributed so far. Circulation now exceeds 2500 per issue and it is distributed all over the world.

We will continue to deliver interesting and relevant information in future issues and the 4th issue is planned for September 1997. Contributions for considerations should be sent to Aston University by June 30th 1997.



▲ *Editorial Team*
Claire Humphreys *Administrator*   Tony Bridgwater *Co-ordinator*

PyNE ISSUE 3 MARCH 1997

Compiled by F. Pinto, INETI - ITE - DTC, Portugal.

7th ISWA - International Congress & Exhibition

This congress took place in Yokohama, Japan, 27 October to 1 November, 1996. ISWA (International Solid Waste Association) is an association of individuals, public and private companies, authorities and solid waste association from 70 countries. The primary objectives of this congress were:

- the maximum exchange of information and experience worldwide on all aspects of solid waste management.
- the change of opinions on possible solutions to these problems among waste management specialists from different fields across the world.

Several oral presentations were presented in parallel sections about the following themes:

1. Waste Minimisation
2. Waste Recovery and Recycling
3. New Developments in Waste Treatment & Disposal - Thermal Treatment
4. New Developments in Waste Treatment & Disposal - Landfill
5. New Development in Waste Treatment & Disposal - Special Techniques
6. Policy, Planning and Strategy - Industrial Waste Management
7. Policy, Planning and Strategy - Municipal Waste Management
8. Jonhkasu System
9. International Perspective
10. ISWA Working Groups

During this congress poster sections were held depicting major concerns of the conference and ISWA. The following topics were chosen:

1. Waste Minimisation
2. Waste Recovery and Recycling
3. New Developments in Waste Treatment & Disposal
4. Policy, Planning and Strategy
5. Jonhkasu System
6. Waste Water Treatment
7. International Perspective

All papers concerning oral presentations and posters were published in two books of proceedings by the conference organisation.

R'97 - Recovery, Recycling, Re-integration

This conference took place in Geneva, Switzerland, 4-7 February, 1997. Several hundreds of professionals debated subjects essential for the sustainability of our society, namely recovery, recycling and re-integration of earth resources and their integrated management. The aims of this congress were to:

- strike a balance between science, industry and legislation,
- consider ecological, economic and social factors and implications
- lead to environmentally and economically acceptable solutions, through the active involvement of all interested parties,
- show the latest developments in recovery, recycling and re-integration technologies.

The programme was divided into 18 main areas with oral presentations and posters, which included:

- Integrated Resources Management
- Integrated Waste Management, Concepts, Regulatory Issues
- Thermal Processes - General Schemes
- Chemical Processes
- Economic Choices
- Socio-economic Issues
- Thermal Special Processes

During this congress several workshops took place including thermal processing.

About 180 oral presentations, presented in parallel sections and around 150 posters are included in the proceedings, edited by Dr. Anis Barrage and Dr. Xaver Edelmann and published by EMPA 1997.

Gasification and Pyrolysis of Biomass - State of the Art and Future Aspects and The third Meeting of the EU-Canada Collaboration on Thermal Biomass Conversion

Venue: Stuttgart, Germany
Date: **9-11 April 1997**
Content: *The state of the art of gasification and pyrolysis of biomass will be presented and the necessary steps for further development will be discussed. Technical Subjects: Introduction (Biomass for Energy in Europe, Status and Prospects - Overview of Gasification of biomass in Europe - Overview of pyrolysis of biomass in Europe) - Fuel Characteristics and Pre-treatment - Gasification technology - Pyrolysis Technology - Utilisation of Gasification Products - Utilisation of Pyrolysis Products - R,D&D needs for Gasification and Pyrolysis in Europe.*
Contact: M. Kaltschmitt, L. Dinkenbach, Institute for Energy, Economics & The Rational Use of Energy (ER), University of Stuttgart, Hessbruehlstrasse 49a, DE-70565 Stuttgart, Germany.
Tel: +49 711 780 610
Fax: +49 711 780 6177

The European Congress on Renewable Energy Implementation

Venue: Astir Palace, Vouliagmeni, Athens
Date: **5-7 May 1997**
Contact: Prof. A Zervos, Secretary General of the Congress CRES, 19th km Marathonos Ave., GR - 190 09 Pikermi
Fax: +30 1 60 39 911, 904

Third European Works on Chemistry, Energy & the Environment

Venue: Portugal
Date: **25-28 May 1997**
Contact: Prof. C A C Sequeria, Instituto Superior Technico, Av. Rovisco Pais, 1096 Lisbon Codex, Portugal
Tel/Fax: +351 1 7783594

The World Waste-to-Energy Conference and Exhibition

Venue: Amsterdam
Date: **27-29 May 1997**
Contents: *The conference will address the main issues of power generation from waste materials with particular emphasis made on flue gas emission and waste ash, and the impact of waste-to-energy on recycling initiatives.*
Tel: +44 171 582 7278
Fax: +44 171 793 8007

9th International Symposium on Wood and Pulping Chemistry

Venue: Montréal, Quebec, Canada
Date: **9-12 June 1997**
Contact: Mr Glen Black, Technical Section, CPPA, 1155 Metcalfe St. Suite 1900, Montreal, QC, Canada, H3B 4T6.
Tel: +1 514 866 6621
Fax: +1 514 866 3035
Email: cppatec@ibm.net

Frontiers in Pyrolysis '97: Detection, Identification, Characterisation

Venue: Plymouth State, NH, Denmark
Date: **22-27 June 1997**
Contact: Gordon Research Conference Office, University of Rhode Island, PO Box 984, West Kingston, RI 02892-0984
Tel: +45 401 783 4011
Fax: +45 401 783 7644

Sustainable Agriculture for Food, Energy & Industry

Venue: Germany
Date: **22-28 June 1997**
Content: *The aim of the conference is to discuss, disseminate and utilise results obtained by scientists from different countries and regions to develop appropriate strategies towards sustainable management of natural resources. Emphasis will be put on aspects related to integrated agriculture production systems for good and raw materials for industrial and energy uses.*
Contact: Federal Agricultural Research Centre (FAL), Institute of Crop Science, Bundesallee 50, D-38116 Braunschweig, Germany
Fax: +49 531 596 365

Fourth International Conference on Technologies and Combustion for a Clean Environment

Venue: Lisbon, Portugal
Date: **7-10 July 1997**
Contact: Prof. Maria da Graça Carvalho
Mechanical Engineering Department, Instituto Superior Técnico Av. Rovisco Pais, 1096 Lisbon Codex, Portugal
Tel: +351 1 841 73 72/841 71 62
Fax: +351 1 847 55 45/726 26 33

Third Biomass Conference of the Americas

Venue: Montreal, Canada
Date: **24-29 August 1997**
Content: *The conference will provide an international forum in support of the development of a viable biomass-based industry. The emphasis will be on how to make a profitable business from biomass within a vision of sustainability. Technical Subjects: Resource Base - Electricity Production - Transportation Fuels - Chemicals, Fibres and Materials - System Analysis: Energy and Co-products - Sustain ability and Environmental Impacts - Life Cycle and Techno economics - Business Development for Biomass-based Industries.*
Contact: Mr E Hogan, Natural Resources, 580 Booth Street, 7th Floor, Ottawa, Ontario, Canada, K1A OE4
Tel: +1 613 996 6226
Fax: +1 613 996 9416
OR: Esteban Chornet (echornet@coupal.gcm.usherb.ca) or Ralph P. Overend (overendr@tcplink.nrel.gov)

Fifth Brazilian Symposium on the Chemistry of Lignin and other Wood Products

Venue: University of Paran, Brazil
Date: **August 31 - September 4, 1997**
Content: *Biomass to ethanol; modification enzymes for fibre and lignin; Chemical and structural characterisation and lignin and other wood components; alternative uses of biomass.*
Contact: Jack Saddler, IEA activity leader, Forest Products Biotechnology, The University of British Columbia, 2357 Min Mall - Vancouver, BC Canada.
Tel: +55 604 2223267
Fax: +55 604 2223220
Email: saddler@unixg.ubc.ca

2nd International Biomass Summer School

Venue: Graz, Technical University (Austria)
Date: **15th to 19th September, 1997.**
Content: *Combustion, Gasification and Pyrolysis of solid biomass fuels; fuel characterisation and preparation, innovative CHP technologies, environmental aspects.*
Contact: Dr Ingwald Obernberger, Institute of Chemical Engineering, University of Technology Graz, Austria.
Tel: +43 316 481300
Fax: +43 316 4813004

International participation is encouraged.

World Power and Energy '97

Venue: Birmingham, United Kingdom
Date: **7-9 October 1997**
Contact: Allan Gibbs, Nexus Media Ltd.
Tel: +44 1322 600070
Fax: +44 1322 667633

The Asia-Pacific Initiative - For Renewable Energy & Energy Efficiency

Venue: Jakarta Convention Centre - Indonesia
Date: **14-16 October 1997**
Contact: ADA Ltd, 5/F 3 Wood Road, Wanchai, Hong Kong
Fax: +852 2574 1997
Email: altdev@hk.super.net
WWW: http://www.hk.super.net/~altdev/

Dynamotive Technologies
develops value added products from Bio-Oil

By Raymond McAllister, Vancouver, Canada.

For DynaMotive Technologies Corporation, bio-oil generated from flash pyrolysis is much more than a biomass derived substitute for fossil fuel. The company is developing a unique Biomass Refinery family of value added products for air emissions control, while at the same time perfecting its proprietary BioTherm™ pyrolysis process.

BioLime™ is DynaMotive's highest value Bio-oil derived fuel additive. When used in coal-fired combustors, it reduces coal consumption, lowers operating costs compared to conventional SOx and NOx reduction technologies, and significantly reduces harmful emissions responsible for smog, acid rain and global warming. The product has been tested in a 100 kW coal combustor at Penn State University and has achieved high levels of emission control, with SO_2 capture rates of 90-95% and simultaneous reduction of NOx emissions by 50-55%. Small quantities of another DynaMotive product called Noxolene™ can also be added to dramatically enhance NOx reduction.

▲ *Dynamotive BioLime Demonstration Plant in Vancouver, Canada.*

The core of the Biomass Refinery is a flash pyrolysis process developed by one of DynaMotive's partner companies, Resource Transform International, Ltd. (RTI) in Waterloo, Ontario. Biomass feed stock is flash pyrolyzed to produce liquid bio-oil or an aerosol called BioSol™. Both products can be used either as clean burning fuels or can be refined to make value added emissions control products. The current generation of the fast pyrolysis system incorporates many important and novel features to increase yield, quality and operating efficiency.

In September, 1996, DynaMotive completed construction of a 25 ton per day capacity BioLime™ demonstration plant in Vancouver (see photos). The company is currently designing a BioTherm™ plant of similar size to make bio-oil from recycled wood, agricultural and municipal solid waste.

DynaMotive recently signed an agreement with Chase Manhattan Bank to project finance future Biomass Refinery projects in Europe. The company is actively pursuing strategic alliances partners in Europe and the UK, and eventually plans to develop a whole range of Biomass Refinery products including slow release fertilisers, octane enhancers, chemicals, plastics and adhesives.

For more information, contact:
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◄ *Dynamotive BioLime Demonstration Plant in Vancouver, Canada.*

Pyrovac Institute
launches a new reactor
enhancing heat transfer efficiency

continued from page 1.

By Professor C. Roy.

President, Institut Pyrovac Inc.. Parc technologique du Quebec metropolitan,

333 rue Franquet, Sainte-Foy (Quebec), G1P 4C7.

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The new reactor design includes a novel feedstock transport and agitation system and uses an indirect heating system involving Hitec® molten salts. The agitation system produces an increased heat exchange between the feedstock particles at the surface of the heating plate and the colder particles located at the core of the bed of particles. The molten salts flow across tubes below the heating plates in the reactor to indirectly heat the feedstock conveyed over the heating plates. The salt temperature is controlled by means of induction heating. This new reactor configuration is of great importance for vacuum pyrolysis technology as it will enable increased reactor throughput capacities.

Pyrocycling™ process

This is a patented process which involves the thermal decomposition of any organic material under specific conditions such as reduced pressure, heating rate and temperature in order to produce useful products. The process successfully enables the production of large quantities of pyrolytic oils and charcoal from a large variety of organic waste materials. Pyrolysis oils derived from biomass have shown to be the source of fine chemicals or can be used for the production of heating fuels and in the manufacture of resol resins.

A joint-venture with Ecotechniek b.v.

Pyrovac International signed in August 1996 an agreement in which Ecotechniek acquired 50% of Pyrovac International shares. Ecotechniek is a company in the Netherlands with a vast environmental expertise. Ecotechniek is a subsidiary of UNA, a Dutch utility company, jointly owned by the cities of Amsterdam and Utrecht. UNA, owner of two thirds of Ecotechniek's shares, is active in the field of electricity generation and distribution. The shareholder of Ecotechniek is Royal Volker Steven, a Dutch public corporation, with annual earnings of about $ CDN 2.2 billions in the road construction and related industries. Ecotechniek and Pyrovac Group have the expertise and resources to design, build and assemble all of the hardware needed to set up Pyrocycling™ plants anywhere in Europe. Construction of the first Pyrocycling™ plants in Europe will be announced during 1997.

For further information please contact:
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E-mail: 100625.1261@compuserve.com

Pyrolysis in Norway - Production of Wood Tar

By Morten Fossum

The Norwegian consumption of pyrolysis products is primarily covered by import. The import of charcoal has increased from 25,000 tons in 1990 to 55,000 tons in 1994, while the import of tar is in the range of 100-200 tons per year. These figures shows a potential market for a Norwegian pyrolysis industry. Feasibility studies of a commercial pyrolysis industry shows that it is difficult to compete with the imported products with an average cost of 0.2 ECU per kg of charcoal and 1.0 ECU per kg of tar. However, there is a market for high quality tar based on traditional production methods, forest kilns and batch retort processes, and with high resinous pine roots as feedstock.

Two Retorts. One retort is in operation while the other one is cooled down before discharging charcoal. This picture is from the construction period. (step2.)

The forest kiln, or charcoal kiln, has a very long history in Norway. The kiln operated today is primarily of historical interest and to maintain the craft of building up and operate this old technology. The sizes of the kilns are typically in the range of 30-35 m^3 of wood and the yield of tar is in the range of 30-35 kg/m^3 of wood. The retort plants have similarities to the plants that were in use in the period of 1930 and up to 1960. The plants that are in operation today are small scale units, the largest plant has two retorts of 3.5 m^3 and an annual production of 15,000 litres of tar and operates only during the summer.

The retort plant is typically a batch process where biomass is fed into the retort on the top and the charcoal remaining after the process is discharged at the bottom of the retort. The retort is heated up by reheating the circulating gas in the system in a heat exchanger. The gas is heat exchanged with flue gas from combustion of biomass and/or combustion of pyrolysis gas.

▲ Pine roots as received. The plant is situated at Oppdal. 130km south of Trandheim, and a very popular area for skiing (downhill).

Pyrolysis in Norway - Production of Wood Tar

continued...

The temperature of the gas entering the retort is set to be in the range of 500-600°C. Tar and water are separated from the pyrolysis gas in the condenser where the gas is cooled down to approximately 20°C. In order to reduce fouling problems, the gas is led to a gas scrubber before entering the heat exchanger. The yield of tar for this process is in the area of 60-80 kg/m3 of wood, depending of the quality of the feedstock.

The kiln after 15 hours of operation. The total operation time for this kiln was 45 hours. The tar production started after 5 hours.

Prices for the tar produced in these units is in the area of 8-15 ECU/litre and the product is primarily used for impregnation of buildings and boats. The charcoal is sold locally and is, at the moment, regarded as a none-valuable by-product.

Condensers, fan for situation of pyrolysis gases and one operator.

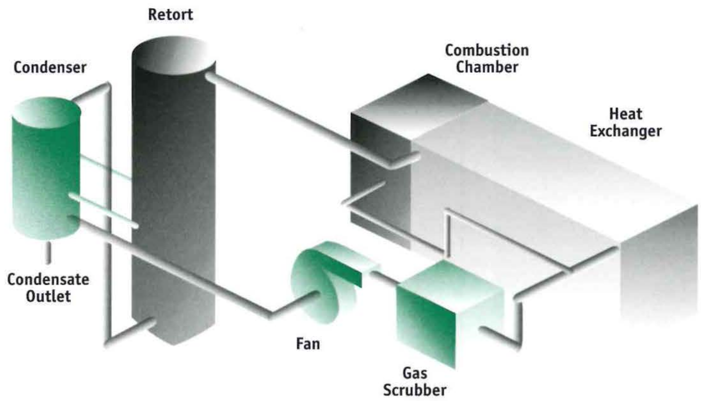
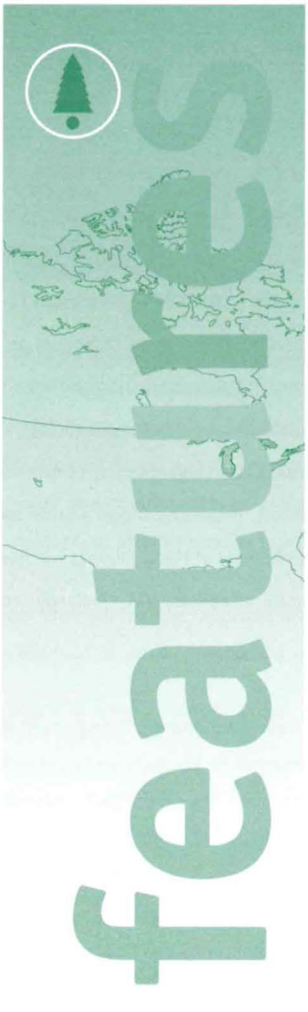


Figure 1: Pyrolysis Retort for Charcoal and Wood Tar Production. A Schematic View of the Plant and the Process units



NEWS from North America...

Research News

By Ed Hogan, Natural Resources, Canada.

Orenda Aerospace has recently completed a major milestone test in their project to develop a gas turbine that can utilize pyrolysis oils to generate electricity. The test involved the evaluation of two separate combustion liner designs, a conventional one and one that has been modified as a result of the analytical work Orenda has performed on the pyrolysis oil. The tests were carried out on 100% pyrolysis oil at full power.

The CANMET Energy Technology is continuing the development of its microemulsion technology that allows pyrolysis oil to be mixed in conventional diesel fuel in ratios ranging from 5-30%. In the latest development, a 5 litre per hour continuous unit has been built and is undergoing preliminary testing to demonstrate that the process can be scaled up to this size.

The University of Saskatchewan is beginning a project to examine the steam gasification of chars. Preliminary results indicate that the char could be capable of producing a high BTU gas using this process.

Research is also underway to carry out pyrolysis oil over a variety of catalysts - HZSM-5, HY, mordenite, molecular sieves (SAPOs), silica-alumina and mixtures of HZSM-5+/silica-alumina.

Further information on these projects and on the Canadian bio-energy research and development program can be obtained from Ed Hogan, Natural Resources, Canada.

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features

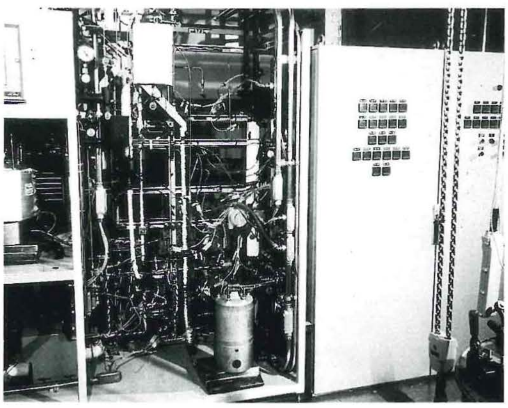
Biomass Pyrolysis a

By Stefan Czernik, - NREL, 1617 Cole Boulevard, Golden, Colorad

Biomass pyrolysis activities in the USA are concentrated at the National Renewable Energy Laboratory (NREL) at Golden, Colorado. Currently, three Department of Energy programs support the pyrolysis based research on converting biomass to fuels and chemicals: Industrial Technologies, Biomass Power, and Hydrogen. The equipment includes: small-scale (100 mg) reactors coupled to the molecular-beam mass-spectrometer (MBMS); a bench-scale (100 g/h) fluidized bed reactor; and two larger-scale (20 kg/h) vortex reactor systems. In addition, there is a system for fractionation of pyrolysis oils to isolate phenolic fraction used for adhesives formulations and a bench-scale fixed-bed catalytic steam reformer for converting pyrolysis oils to hydrogen.

The MBMS experiments are usually conducted to study mechanisms of the processes (Evans and Milne; Wang et al.) and to screen and select catalysts for conversion of biomass and its products (Wang et al.).

The bench-scale fluidized bed unit has been used to determine optimum conditions for hot filtration of pyrolysis vapour in order to minimise oil losses by thermal cracking, and to study properties of oils generated from different feedstocks (Agblevor et al.).

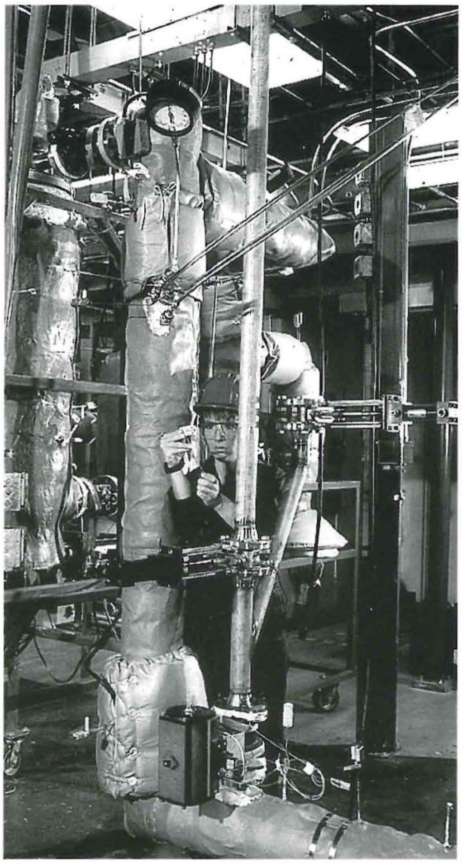


▲ *Bench-Scale circulating fluidized bed unit*

The vortex reactor system at NREL has been significantly modified during the past year. At present, it includes the vortex pyrolysis reactor, a vapour cracker, two cyclone separators in series and a baghouse filter for char removal, and a product collection train comprised of three scrubbers, two electrostatic precipitators, and two coalescing filters. The unit is equipped with a state-of-the-art data acquisition and control system and with on-line analytical instruments (gas chromatographs, FTIR spectrometer, MBMS) that allows sampling vapours and gases at different sites. In 1996, several experiments were conducted with the objective of generating gaseous products rather than liquid oil. The second vortex reactor unit is located at a site of Hazen Research, Inc. in Golden, CO. The throughput of this unit is about 25% greater than the one at NREL. Similar to the latter, it is also fitted with a baghouse filter for separation of char from the vapours but the product collection train is different: the vapours are condensed in a venturi scrubber and in two shell and tube condensers. Supported by the Biomass Power Program, this unit was used to produce barrel quantities of low ash (0.01-0.02%), low alkali (1-2 ppm of potassium and calcium) poplar oil (Scahill et al.). This oil showed very good combustion characteristics in a single droplet combustor at Sandia National Laboratories (Shaddix and Huey). Sandia also conducts spray combustion test of the hot-filtered oil. Promising Diesel engine test results on this oil were obtained at Massachusetts Institute of Technology, University of Kansas, VTT (Finland), and Ormrod Diesels (UK).

tivities in the USA in 1996

80401-3393, USA. *Tel: +1 303 275 3821 · Fax: +1 303 275 3896 · Email: czerniks@tcplink.nrel.gov*



Vortex Reactor Pyrolysis/gasification unit - hot vapour baghouse filture

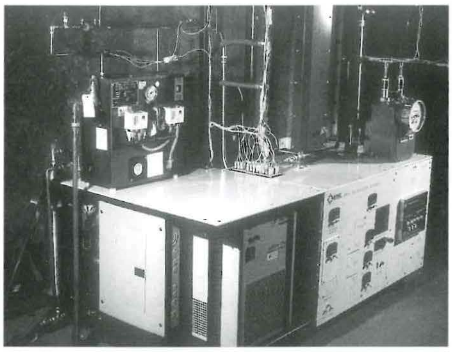
In addition to the development of fuels from pyrolysis oils, NREL has also been working on other applications for pyrolysis products. Within the Industrial Technologies Program, the work continues on the recovery and modification of phenolic fraction for formulation of phenol-formaldehyde resins (Kelley et al.). Modified aqueous fraction of pyrolysis oil has been studied for the application in brightness stabilisation of thermo-mechanical pulps.

The Hydrogen Program involves catalytic steam reforming of pyrolysis oil or its fractions to generate hydrogen. Very successful bench-scale experiments with model compounds and aqueous oil fraction were conducted using a fixed-bed reformer (Czernik et al.). Almost quantitative conversion of the oil fraction to gaseous product was obtained with 86% yield of hydrogen.

Work on upgrading pyrolysis oil by mild hydrogenation has been conducted at Pacific Northwest Laboratory (PNL) by Elliott. An overview on upgrading was presented at the Developments in Thermochemical Biomass Conversion Conference in May 1996 (Maggi and Elliott).

Fundamental work on biomass pyrolysis has been conducted at University of Hawaii (Narayan and Antal) and at Brown University (Milosavljevic, Oja, and Suuberg). They studied kinetics and thermal effects of pyrolysis of cellulose using TGA.

Mathematical modelling of biomass pyrolysis has been carried out at the Jet Propulsion Laboratories (Miller and Bellan). At the current stage, the model represents very well the process occurring during a TGA experiment. It is being developed to also include fast pyrolysis processes.



Fixed-bed Catalytic steam reformer

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Combustion of Pyrolysis Liquids

By Steven Gust, Finland

Critical Issues

With the scale up of fast pyrolysis production to the tonnes per day level, large quantities of product are being made available for application testing. Applications include turbines, stationary diesels or boilers. Initial testing has shown that emissions can be reduced to acceptable levels and currently the emphasis is on developing and modifying existing systems to handle the specific requirements of pyrolysis liquids. The aim in application development is to adapt systems so that upgrading can be avoided. Fuel quality is the critical issue and the main properties of interest are viscosity, contaminant levels of char and ash and fuel stability. While viscosity and contaminant levels can be adjusted and handled by modifying production conditions, fuel stability or reactivity is much more difficult to control with present processes. Stability of pyrolysis liquids includes tendency to phase separate, to polymerise, to coke at high temperatures, to oxidize and to form thick films.

Finnish Fuel Prices and Pyrolysis Use

Pyrolysis liquids could replace either heavy or light fuel oils. In practise, heavy fuel oils begin to be used when boiler size is larger than 1 MWth and yearly consumption is large. Light fuel oils are normally restricted to small boilers (<1 MWth). This situation varies by country depending on tax rates and heating market structure.

In Finland, average light fuel oil prices in 1996 were 1.5 FIM/litre (0.27 ECU) while heavy fuel oil sold for 1.14 FIM/kg (0.21 ECU). These prices included taxes of 0.45 FIM/l and 0.39 FIM/kg respectively. On an energy basis the consumer prices are 150 and 100 FIM/MWh. Replacing heavy fuel oil with pyrolysis liquids is not likely since pyrolysis production costs (including feedstock at 50 FIM/MWh) are estimated to range from 120-150 FIM/MWh. This also means that power production in turbines and diesels is difficult since fuel costs cannot in general be greater than heavy fuel oil prices. The heavy fuel oil market has in fact been switching to cheaper solid fuels such as coal, peat and wood chips or natural gas where available.

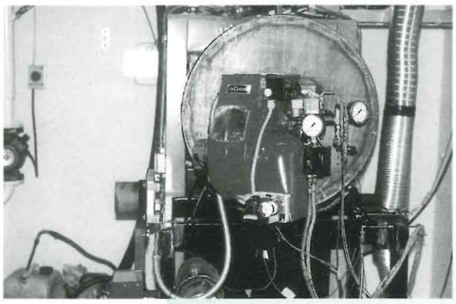
Of the light fuel oil market, the combustion of pyrolysis liquids in small residential boilers (<20 kWth) is not likely due to fuel quality concerns. On the other hand, our tests have shown that use in intermediate size boilers, on the order of 100 kW to 1 MW (about 20-200 pyrolysis litres/hour input) combustion is possible.

Resource Base

The resource base in Finland is considered to be adequate for the production of pyrolysis liquids. Biomass based fuels already contribute to over 15% of national energy demand but mostly in the form of industrial wastes (pulping liquors, sawmill bark etc.). In the context of a national bio-energy programme, it has been calculated that the use of wood based biomass in the form of forestry residues can be increased by up to 15 million cubic meters or 2.6 Mtoe which is an additional 9% of total energy demand. Within the same programme the cost of residues has been reduced by over 50% within the past 4 years from 90 to 55 FIM/MWh (16 -> 10 ECU/MWh) primarily by improving productivity.

Combustion Technology

Pressure atomisation is used exclusively for light fuel oil combustion is. Here a pump raises the pressure of oil to 8-10 bars which is forced through a small hole in a nozzle to produce a fine spray of oil droplets ranging in sizes of 30 to 100 micron diameter. A fan provides air necessary for combustion and the oil droplets are heated, ignited, evaporated and combusted. Light fuel oils are characterized by low viscosity (5-15 cSt at room temperature), low autoignition temperatures (210-240°C) and low residue levels (<0.01%). They are called distillate fuels which means that they do not form coke or leave deposits when heated and evaporated. Heat radiating back to the nozzle after shut off will evaporate fuel in the nozzle but this does not interfere with nozzle operation.



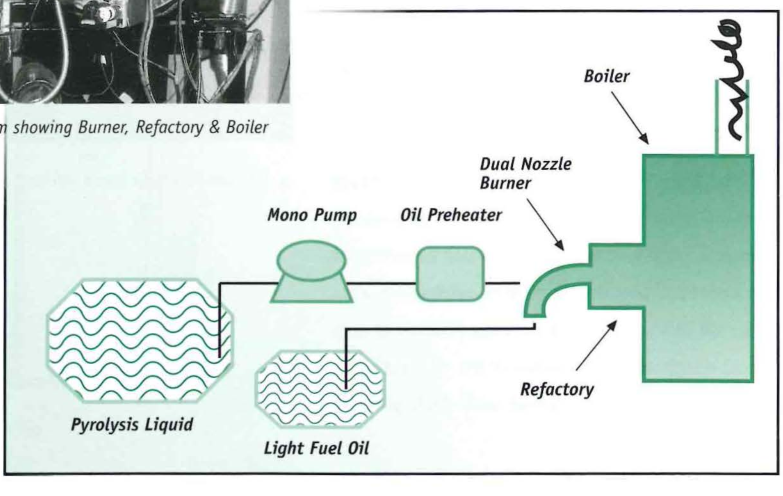
▲ *Combustion System showing Burner, Refactory & Boiler*

The frequency of these on off cycles will depend on boiler sizing and climatic conditions but 1 to 2 cycles per hour is not uncommon. When adapting these systems for pyrolysis use, this cycling behaviour poses significant challenges to the system design. Since pyrolysis liquids contain from 20-25% water they do not readily ignite which means an auxiliary fuel and high temperatures in the boiler is needed. After shut off this heat must not be allowed to radiate back to nozzles containing pyrolysis liquid otherwise thickening and coking will occur.

Combustion Mechanisms: Single droplets

Knowledge of the combustion mechanism is beneficial in the design of burners and boilers. Initial work done by Sandia labs on single droplets indicated that the combustion process is characterized by the following steps: light compounds evaporating from the surface of the drop and combusting with a blue flame; skin formation and internal gas pressure build up followed by a microexplosion of droplets and char burnout. Droplet volume expansion is due to light compounds vaporizing inside drops forming gas bubbles but unable to break through the skin. The skin is thought to be formed from polymerization of various compounds.

An important point was that although the combustion process differs significantly from light fuel oil combustion, the length of time to total burnout was similar. Another point is that these microexplosions forming sparklers are characteristic of pyrolysis liquid combustion and do not necessarily lead to high particulate emissions. On the other hand, their studies used large drops which would not normally form so combustion processes in engines and boilers might not necessarily follow this path.



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Combustion in Boilers

Although precise details are not known, the overall features of pyrolysis combustion in boilers and engines does agree with the single droplet work. The fuel is hard to ignite which is due to high water content. In diesel engines, a pilot fuel is used while in boilers a pilot fuel is not needed but a refractory section is needed to radiate heat back to the drops to evaporate off water. Emissions are between those for light and heavy fuel oils. Nitrogen oxide (NOx) emissions are higher than for light fuel oils due to fuel nitrogen contributions. Particulate levels are higher due to higher fuel solids content. These results were corroborated in studies done in Canmet, Canada and in diesel engine tests in Finland.

Combustion System Modifications

Our work continues on the design, development and testing of a variety of combustion system components. Our goal is to use commercial parts wherever possible. A variety of different refractory lined combustion chambers have been tested. The result of these modifications was that the minimum temperature before pyrolysis oil could be fired was reduced by 200°C and the time to reach this temperature was reduced from 20 to 1 minute. A commercial boiler and a dual nozzle burner were used. Burner control was modified so that two fuels could be combusted simultaneously or independently. A 1 kW fuel pre-heater was used to adjust temperatures in the range 60-90°C. A variety of commercial nozzles were tested including Danfoss, Delavan and Monarch. A Suntec mechanical pressure regulator was used. Nozzles, valves and pressure regulators will require replacement with acid resistant materials. The original oil pump was replaced with a progressive cavity pump. Different pump materials have been tested.

Samples Tested

A variety of samples were tested. Viscosity of samples stored under inert conditions approximately doubled during the 1 year storage. Viscosity was adjusted to initial levels by addition of alcohol's. Phase separation problems were seen with some samples. The best results to date were with hardwood oils.

	Ensyn, Canada		*Union Fenosa, Spain*		
Feedstock	*Hardwood*		*Eucalyptus*	*Pine*	*Straw*
Water wt%	18	23	19	26	28
Solids wt%	0.5	0.7	0.7	0.03	0.02

Combustion Results and Comparison

The basic procedure for testing was to warm up the combustion chamber with mineral oil through nozzle 1 to a minimum of 600-800°C, switch on the pyrolysis pump and pre-heater to raise the temperature to 80-90°C, switch on pyrolysis nozzle 2 and switch off nozzle 1, adjust air for oxygen level in flue gas 6-9%. On shut down it was necessary to rinse system out with alcohol to avoid blocking. The main results of the combustion tests and comparison to other fuels are shown in the table below. Studies into droplet size are shown in the table under Sauter mean diameter. Good correlation was seen with droplet size and viscosity which indicates that to achieve good atomization and combustion, a viscosity of 10-15 cSt at the atomization temperature is desired.

		Medium Light Fuel Oil	*Flash Pyrolysis Liquid*	*Wood Chips*	*Heavy Fuel Oil*
Water content wt%		0.02	18...25	15...20	0.5
Heating Value	*MJ/Kg*	42.4	17.....15	16...12	41
	MJ/l	36.9	21...18	8...6	39.4
Viscosity cSt	*30°C*	9	900....150		600
	50°C	4	150...20		180
	80°C	2	24...6		50
Flash Point °C		90	60...100		80
Solids		-	0.7...0.01		<0.05
Ash wt%		<0.010	0.1...0.01	2...4	0 .03
Sulfur wt%		0.15	0	0	1
Nitrogen wt%		0	0.3...0.1	0.1...0.2	0.3
Sauter diameter	*um*	30-40	60-40		50-70
		10 bar	20 bar		30 bar
		20 C	85 C		130 C
Typical Emissions					
	CO (ppm)	15-30	30-50	500-6000	5-30
	NOx (ppm)	80-120	120-150	80-160	200-400
	particulates (Bach)	0.2-1	2.5-5	+tars, PAH	1-4
	mg/Nm3				50-150
Pour Point C		15	-27		0

Flash pyrolysis liquid properties and emissions compared to alternative fuels.

Conclusions Thus Far

1. Flash pyrolysis liquid can be combusted using simple pressure atomisation equipment and emissions reduced to acceptable levels with proper optimisation of combustion conditions.
2. The combination of high temperatures required for pyrolysis liquid ignition and the thermal instability of the product requires special attention be paid to combustion chamber temperature profiles.
3. Due to problems encountered with storing, pumping, igniting, and keeping nozzles operable after shutdown, it is not likely that present quality levels of flash pyrolysis liquid would meet the requirements of a light fuel oil replacement.

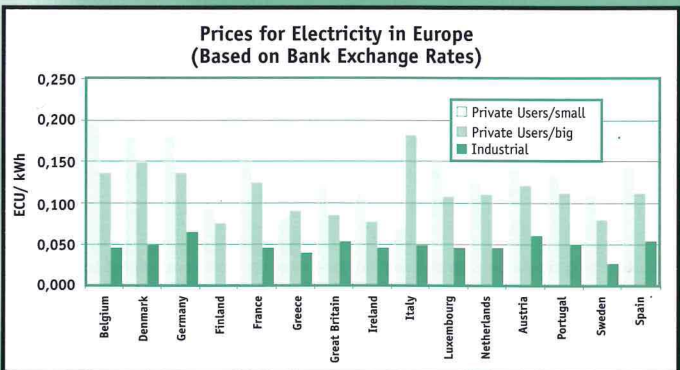
Energy Costs & P

The International comparison of electricity prices is difficult. Electricity suppliers point out that the comparison on the base of bank exchange rates (BER) does not reflect the real situation. Additionally a comparison of prices related on specific purchasing power relations is provided (PPR). In the following table the purchasing power in Germany is set to 100% of exchange rate. All other purchasing powers were related to German DM and further transferred to ECU.

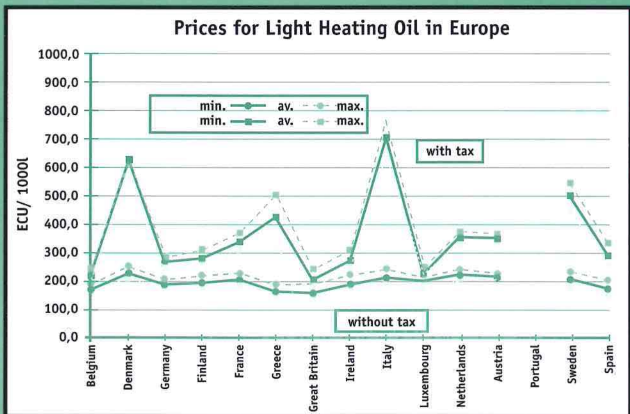
Electricity prices in Europe

Date: Jan. 1996/ Source: VDEW e.V.: EU-Strompreisvergleich Stand 1. Januar 1996/
All prices in ~Ecu/kWh

Country	*Private Users/small* Consumption 1700 kWh/a		*Private Users/big* Consumption 7500 kWh/a		*Industry* Cons: 10 MW; 7000 h/a	
	PPR	*BER*	*PPR*	*BER*	*PPR*	*BER*
Belgium	0.224	0.197	0.153	0.135	0.052	0.045
Denmark	0.155	0.178	0.130	0.149	0.045	0.049
Germany	0.183	0.183	0.135	0.135	0.065	0.065
Finland	0.092	0.094	0.075	0.077		
France	0.166	0.154	0.137	0.127	0.051	0.046
Greece	0.150	0.082	0.167	0.091	0.060	0.039
Great Britain	0.180	0.124	0.126	0.087	0.080	0.054
Ireland	0.153	0.114	0.107	0.079	0.062	0.045
Italy	0.106	0.071	0.274	0.185	0.070	0.050
Luxembourg	0.175	0.154	0.126	0.111	0.048	0.044
Netherlands	0.143	0.128	0.126	0.113	0.051	0.046
Austria	0.150	0.143	0.130	0.124	0.065	0.062
Portugal	0.245	0.136	0.210	0.116	0.090	0.052
Sweden	0.106	0.113	0.078	0.083	0.027	0.028
Spain	0.219	0.147	0.171	0.115	0.081	0.057



Country	*Light Heating Oil*						
	Prices without tax			Prices with tax			Tax
	min	*av.*	max	min	*av.*	max	*av.*
Belgium	158.7	**172.8**	190.1	208.9	**225.7**	246.6	**52.9**
Denmark	216.8	**230.9**	253.4	568.7	**627.9**	617.9	**396.9**
Germany	173.9	**191.1**	204.2	248.2	**268.1**	282.8	**77.0**
Finland	179.1	**195.8**	218.4	261.8	**282.2**	311.0	**86.4**
France	185.4	**204.7**	229.9	316.8	**339.3**	370.7	**134.6**
Greece	138.8	**163.4**	187.5	321.5	**424.2**	504.8	**260.8**
Great Britain	138.8	**160.2**	191.7	179.1	**204.2**	243.5	**44.0**
Ireland	170.7	**189.0**	222.0	248.2	**270.2**	309.5	**81.2**
Italy	183.8	**211.6**	243.5	644.1	**704.3**	763.0	**492.8**
Luxembourg	173.9	**198.5**	216.8	198.5	**227.3**	249.3	**28.8**
Netherlands	202.7	**221.5**	238.3	332.0	**354.0**	373.4	**132.5**
Austria	204.7	**216.3**	227.3	334.1	**351.9**	366.0	**135.6**
Portugal							
Sweden	177.0	**204.2**	228.8	447.2	**498.5**	540.4	**294.3**
Spain	143.0	**169.7**	205.3	256.6	**287.5**	328.8	**117.8**

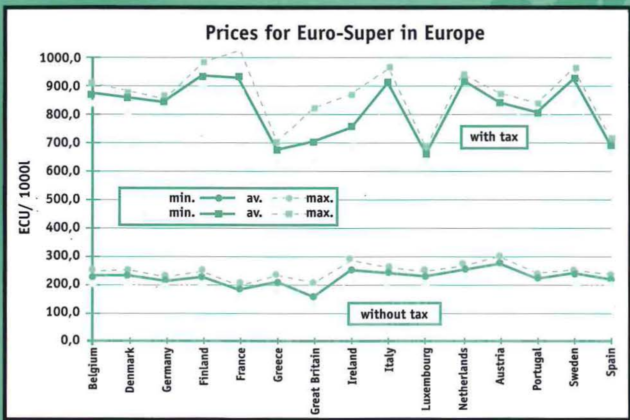


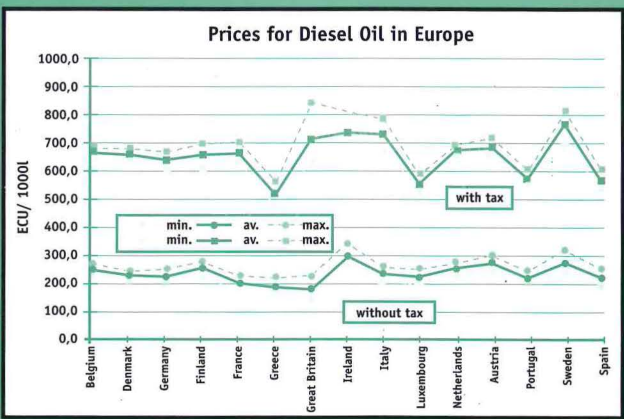
ices in Europe...

by Wolfgang Baldauf - VEBA Oel, Germany.

Country	Eurosuper						
	Prices without tax			Prices with tax			Tax
	min	av.	max	min	av.	max	av.
Belgium	217.8	**240.9**	252.9	842.5	**875.0**	909.6	**634.1**
Denmark	208.9	**242.4**	256.1	814.8	**856.7**	877.1	**614.2**
Germany	201.1	**221.0**	233.5	821.6	**844.6**	858.8	**623.7**
Finland	209.5	**234.1**	252.9	893.3	**932.1**	978.7	**698.0**
France	165.5	**188.5**	204.7	882.9	**930.5**	1035.2	**742.0**
Greece	185.9	**215.2**	237.2	634.1	**673.4**	702.2	**458.2**
Great Britain	137.7	**168.6**	210.0	636.8	**701.7**	825.3	**533.1**
Ireland	223.1	**257.1**	290.6	987.0	**754.6**	866.1	**497.5**
Italy	217.8	**248.7**	265.5	841.5	**915.3**	963.0	**666.6**
Luxembourg	209.5	**236.7**	251.9	633.6	**662.4**	680.7	**425.7**
Netherlands	233.5	**259.7**	273.3	895.4	**922.7**	938.4	**662.9**
Austria	256.6	**284.3**	304.2	817.4	**848.3**	874.5	**564.0**
Portugal	218.9	**228.3**	248.2	783.4	**805.9**	841.0	**577.6**
Sweden	213.6	**248.2**	260.3	839.4	**924.2**	960.9	**676.0**
Spain	207.9	**227.8**	243.0	669.2	**691.7**	711.6	**463.9**

Country	Diesel						
	Prices without tax			Prices with tax			Tax
	min	av.	max	min	av.	max	av.
Belgium	236.2	**252.4**	269.7	645.7	**663.5**	686.0	**411.1**
Denmark	216.8	**229.4**	245.6	642.0	**657.2**	679.7	**427.8**
Germany	207.9	**228.3**	255.0	612.1	**635.7**	666.6	**407.4**
Finland	224.1	**253.4**	278.6	612.1	**656.1**	695.4	**402.7**
France	177.5	**198.5**	228.3	633.6	**662.4**	703.0	**463.9**
Greece	160.8	**187.5**	222.0	478.1	**516.3**	560.8	**328.8**
Great Britain	145.6	**178.0**	226.2	635.7	**710.6**	841.5	**532.5**
Ireland	265.0	**294.3**	341.9	681.8	**734.2**	809.6	**439.9**
Italy	210.0	**233.5**	259.2	675.5	**730.5**	781.8	**496.9**
Luxembourg	196.4	**222.0**	249.3	524.2	**552.4**	584.4	**330.4**
Netherlands	234.6	**252.9**	269.7	653.5	**675.0**	692.3	**422.1**
Austria	247.7	**271.2**	298.0	653.5	**680.2**	715.3	**409.0**
Portugal	205.3	**217.8**	242.4	552.4	**570.8**	597.0	**352.9**
Sweden	247.2	**273.9**	318.9	700.6	**765.6**	808.5	**491.7**
Spain	194.3	**218.9**	252.4	535.7	**564.0**	604.8	**345.1**





Supplementary & Modified Internet Addresses to newsletters 1 & 2.

GOVERNMENT

Energy Efficiency and Renewable Energy Network. - BIOMASS FUELS	http://www.osti.gov/html/eren/09.html
UTAH office of Energy Services	http://energy.aste.usu.edu/docs/
The energy efficiency and renewable energy database	http://www.doe.gov/html/eren/eren.html
U.S. Department of Energy. Alternative Fuels Data Centre	http://afdc.nrel.gov
U.S. Department of Energy. Energy Efficiency and Renewable Energy Network	http://www.eren.doe.gov
Patent and Trademark Information Resources on the Internet	http://www.uspto.gov/other.html
Biofuels Information Network	http://www.esd.ornl.gov/bfdp
Documents dealing with PTO, PCT and other patenting bodies	http://sunsite.unc.edu/patents/ptodoc.html
IEA Bioenergy	http://www.abdn.ac.uk/ieabioenergy/

RESEARCH ORGANISATIONS

Oregon University	http://zebu.uoregon.edu/1996/ph162/119.html
NREL. Biomass Heat Exchanger Furnace	http://syssrv9vh.nrel.gov/Access/commercial_tech/bl.heat.html
Institut für Thermische Energietechnik ITE	http://www.ite.maschinenbau.uni-kassel.de
National Microelectronics Research Centre, IRELAND. Renewable Energy Multimedia System	http://nmrc.ucc.ie/biomass/bmintro.html
Information Service of the Center for Renewable Energy and Sustainable Technology, Washington and San Francisco, USA.	http://solstice.crest.org
BIOENERGY (home page)	http://calvin.biotech.wisc.edu/jeffries/index.html
Energy Resources Division	http://www.commerce.state.mi.us/opla/ehome.htm

INDUSTRY

STN International	http://www.fiz-karlsruhe.de/stn.html
ECN reports	http://www.ecn.nl/

NETWORKS AND ASSOCIATIONS

Biomass Energy Alliance's Web	http://www.biomass.org/
Renewable energy in France	http://www.edf.fr/html/en/mag/renouv/4.htm
PyNE	http://www.ceac.aston.ac.uk/PyNE/
Biomass Information Sources on Internet	http://ensolar.ee.tu-berlin.de/iscb/biomass/bio2.html
Alfa Network	http://www.passagen.se/alealfa
Non-Food Agro-Industrial Research Information Dissemination Network	http://www.cplscientific.co.uk/nf.airid/

EC

European Union's goals and policies	http://europa.eu.int/en/comm/dg12
Specific programmes managed by DG XII	http://europa.eu.int/en/comm/dg12/specpr.html
DG XII home page	http:// europa.eu.int /en/comm/dg12/dg12tst2.html

NEWSLETTERS, BULLETINS AND JOURNALS

Renewable & Sustainable Energy Reviews *(quarterly newsletter)*
Elsevier Science Limited. The Boulevard, Langford Lane, Kidlington, Oxford, OX5 1GB, England
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Fax: +44 (0) 1865 843010

The Liquid Biofuels Newsletter *(Information from the Liquid Biofuels Activity - quarterly newsletter)*
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Bun-India - Biomass Users Network India *(quarterly newsletter)*
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The ITPS Report *(10 times yearly)*
The IPTS Report Secretariat IPTS, JRC Sevilla, World Trade Centre, Isla de la Cartuja, E-41092 Sevilla, Spain
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Biomass News
Biomass News, Ademe Scientific Directorate, 27 rue Louis Vicat, 75737 Paris Cedex 15, France
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COGEN *(Euro-Asean biomass energy project)*
COGEN Programme Secretariat at AIT, GPO Box 2754, Bangkok, 10501, Thailand
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Wood Fuel *(Technologies and Development)*
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The Solar Letter
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IEA Bioenergy NEWS *(provides news)*
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book reviews

CONTRIBUTIONS If you wish to submit a review of a book, please contact Professor L. Conti *(address at end of newsletter)* who is the co-ordinator of this task.

Developments in Thermochemical Biomass Conversion

Edited by A. V. Bridgwater and D.G.B. Boocock

London 1997, 1648 pp, 2 Vol. £ 199, US $ 325

Blackie Academic & Professional, 2-6 Boundary Row, London SE1 8HN, UK

There have been many developments in the science and technology of thermochemical biomass conversion in recent years, especially as concerns over the greenhouse effect and other environmental problems grow. Thermal processing provides an efficient, environmentally acceptable and potentially cost effective method of providing liquid and gaseous fuels and electricity, and in the longer term, speciality and commodity chemicals and transport fuels.

The work, published in two volumes reports the papers resulting from the International Conference on Developments in Thermochemical Biomass Conversion, 19 - 24 May 1966, Banff Canada. This book covers all aspects of thermochemical biomass conversion systems and is divided into five main areas covering pyrolysis, pre-treatment, gasification, combustion and system studies and this division is reflected in the structure of these conference proceedings. Each main section was preceded by a state-of-the-art review to provide a focus for the ensuing presentations and an authoritative reference.

- In the pyrolysis section, firstly, fundamentals aspects and laboratory experimentation and pilot plants are reviewed. Subsequent chapters are dedicated to the last developments on the analysis and characterisation of pyrolysis liquids, the bio-oil combustion, the recovery of valuable chemicals and on the bio-oil upgrading.
- The second section is dedicated to the pre-treatment of biomass before the thermochemical processes.
- Significant developments in the gasification technology are reported in the third section which opens the second volume of the work. The papers presented cover fundamental works, experiments on laboratory, pilot and demonstrative plants, the upgrading of the gas and some commercial realisations.
- Twenty papers are collected in the fourth section on the combustion of biomass and on the problems which could arise with the respect to the environment.
- The work ends with a section dedicated to bio-energy systems studies.

Energy From Crops

Edited by D P L Murphy, A Bramm and K Walker

Cambridge 1996, 362 pp., £28

Semundo Limited, 49 North Road, Great Abington

Cambridge CBI 6YA UK.

Presently in Europe only 2.5% of the total energy demand is generated from biomass sources. EU predictions suggest that by 2050, as much as 30% of our energy requirements could be supplied from renewable energy sources. Such a new industry relies on effective decision making on the part of farmers, industrialists and those who channel the public funds required to kick start new enterprises.

This Book has drawn upon the experience and knowledge of top European experts within the biomass industry and this 362 page publication is a must for those involved or interested in this exciting subject.

Energy from Crops has been written as an aid to decision making, offering timely knowledge covering political, economic, agronomic, environmental and engineering factors concerning this emerging industry.

Sourcebook of Methods of Analysis for Biomass & Biomass Conversion Processes

T. A. Milne, A.H. Brennan ,B.H. Glenn

London 1990, 430 pp.

Elsevier Science Publisher LTD ,Crown House, Linton Road,

Barking, Essex IG11 8JU, UK.

Since the oil embargo of the 1970s, researchers around the world have made tremendous progress in developing and improving methods for converting biomass trees, plants, and organic wastes to useful fuels and chemicals. However, the lack of relevant standards and analytical methods has made comparison of results between laboratories and nations difficult. This Sourcebook of Methods of Analysis for Biomass and Biomass Conversion Processes is the result of an international effort to begin to fill this gap.

Each section of the sourcebook includes citations of both standard methods and literature methods. The sourcebook lists only citations and abstracts (where available) to save space and abide by copyright limitations. Citations include information on availability. Complete addresses of sources of standards are provided in Appendix II.

Reports on other tasks within the IEA Standards Activity are included in the appendices. The Finland report on small combustor efficiency is Appendix III. Reports on the round robin tests are included in Appendix IV. Recommendations on selection and pre-treatment of standard reference materials are presented in Appendix V. The last two appendices may also be helpful. Appendix VI lists additional sources of information. Appendix VII presents a glossary of terms related to biomass.

Biomass for Energy and the Environment

Proceedings of the 9th European Bio-energy Conference

Edited by P. Chartier, ADEME, France, G. L. Ferrero, European Commission, DGXVII, U. M. Henius, Danish Energy Research Programme, Denmark, S. Hultberg, Danish Energy Agency, Denmark, J. Sachau, European Commission, DGXII and M. Wiinblad, Danish Energy Agency, Denmark.

ISBN 0-08-042849-5, Hardbound

The 9th European Bioenergy Conference was held in Copenhagen, 24-27 June 1996. Interest in the conference series continues to grow and the event attracted around 700 delegates from 45 countries. In contrast to previous events, more emphasis was placed on demonstrating bio-energy technology in the marketplace. Overviews on recent achievements in commercial or near commercial activities formed the main focus of the event, but highlights of advances in science and technological development were also presented, in addition to papers covering environmental aspects of bio-energy.

Contents:

The proceedings contain 350 state-of-the-art papers addressing the following areas:

- Primary production of biomass
- Provision and production of solid biomass fuels
- Processes for large power plants
- Processes for decentralised heat and power production
- Processes for production of transportation fuels
- Market, economic and environmental aspects of bio-energy
- Policy measures to overcome non-technical barriers

sponsored exchange visits

As part of PyNE's continued mission to increase awareness of Pyrolysis activities throughout Europe, funds have been set aside to pay for young researchers from PyNE organisations, to visit other laboratories to gain experience and exchange information and ideas. Visit reports are filed with Tony Bridgwater and will be published through this newsletter.

Anne Marie Vergnet - Cirad Forêt

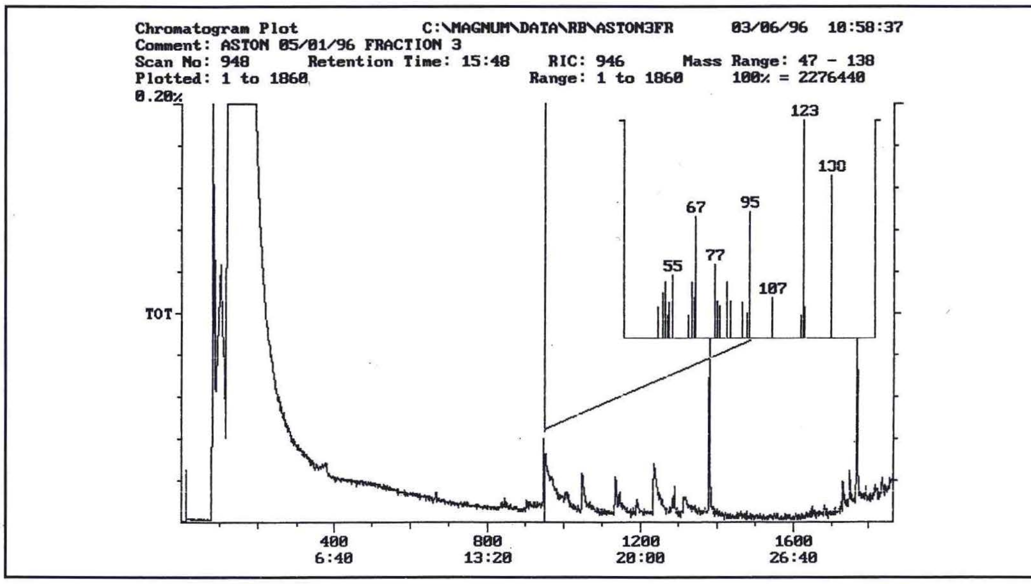
Another researcher to benefit from the exchange experience was Anne Marie Vergnet from CIRAD-Forêt, France. Anne Marie spent 2 weeks, from February 26 to March 8 1996, at the Université Catholique de Louvain, Belgium in the Unité Catalyse et Chimie des Matariaux divisés. The objective of her visit was to compare the bio-oil analysis method used in both laboratories. During her stay, Peter Wulzinger from the Institute of Wood Chemistry of the BFH Hamburg, Germany was also present to study catalytic upgrading which is also reported.

Two oils from Aston University and Twente University were analysed by viscosity, water content, solubility, chromatographic separation, identification and particularly coupled GC/MS which was compared to the CIRAD-Forêt method.

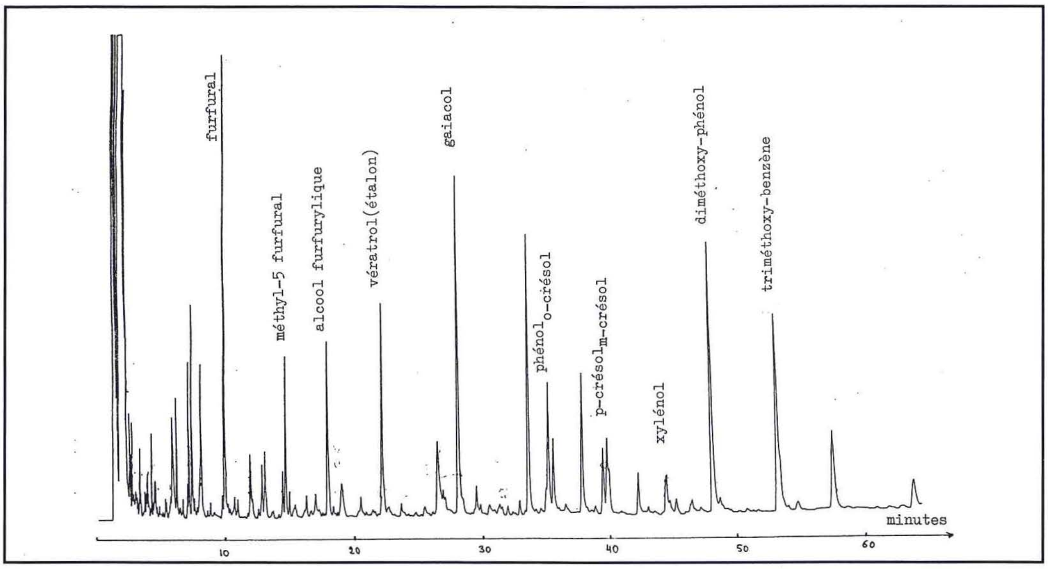
Coupled GC/MS is a qualitative method of analysis and around 100 compounds are identified on a standard basis at UCL. The CIRAD-Forêt method is a quantitative method and about 30 compounds have been identified and quantified. It is interesting to identify and compare the common compounds' identity through GC/MS in UCL and by GC in CIRAD-Forêt. It was surprising to find that apparently only 2 are common : $C_7H_8O_2$ in the UCL's 3rd fraction can correspond to the 2-methoxy phenol identified by CIRAD, and in the 4th fraction, the $C_3H_6O_2$ is probably propionic acid. Figures 1 and 2 shows these results.

These results will be discussed and compared to those obtained during the Round Robin activities within the PyNE network and standard procedures will be suggested as a result.

VERGNET AM, VILLENEUVE F. : "Technique analytiques applicables aux gaz et jus de pyrolyse de la biomasse tropicale" Cahiers Scientifiques, Bois et Forêts des Tropiques no.9, Juillet 1988.



▲ *Figure 1. GC/MS (UCL)*



▲ *Figure 2. GC (CIRAD-Forêt)*

Peter Wulzinger - Institute of Wood Chemistry, Hamburg

Peter Wulzinger from the Institute of Wood Chemistry in Hamburg also visited Université Catholique Louvain (UCL), Belgium in February 1996 to compare different approaches to the catalytic upgrading of bio-oil. At UCL the Research group of Professor Demon and Professor Grange work exclusively on the development and application on catalysts for heterogeneous reaction. Within this research group Dr Rosanna Maggi is developing alternative catalysts for upgrading bio-oil with the objective of both producing hydrocarbon fuels and for stabilisation of bio-oil. In this context the bio-oil provides the opportunity and application for catalysts development.

At IWC the objective of the work is to stabilise and upgrade bio-oil with the primary objective of improving the quality of the liquid rather than development of catalysts.

The activities of these two institutions of this are entirely complementary and provide a valuable opportunity to exchange and compare working methods and procedures. During the exchange visit 5 experiments were carried out on stabilisation and upgrading of bio-oil.
Newly developed catalysts from UCL and commercial catalysts were employed based on nickel and nickel molybdenum on carbon. The results from these tests are not fully available and are still being evaluated.

The value of the visit was a considerably improved knowledge and understanding of procedures for production and activation of catalysts which can have a significant impact on the efficiency of the resultant catalysts. In addition a detailed awareness was required of the facilities available for producing and testing catalysts; of the testing facilities available; the methodologies employed in screening catalysts; upgrading bio-oils; analysing products and evaluating results.

Bio-oil Analysis & Characterisation

Compiled by Jesus Arauzo, University of Zaragoza.

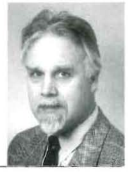
A comprehensive annotated bibliography relating to the chemical and physical analysis of bio-oils and the upgraded products from bio-oils has been compiled and is available on the Internet on the PyNE page at Aston University (http://www.ceac.aston.ac.uk/PyNE/).
The feature is arranged into sections as follows:

1. **Chemical analysis of bio-oil**
2. **Chemical analysis of upgraded products**
3. **Characteristics and properties of bio-oil**
4. **Characteristics and properties of upgraded products**
5. **Characteristics and properties of other liquids**
6. **General and background reading**

Copies of the bibliography are available from the PyNE secretariat at Aston University for those without access to the Internet.

University of Twente

Twente University



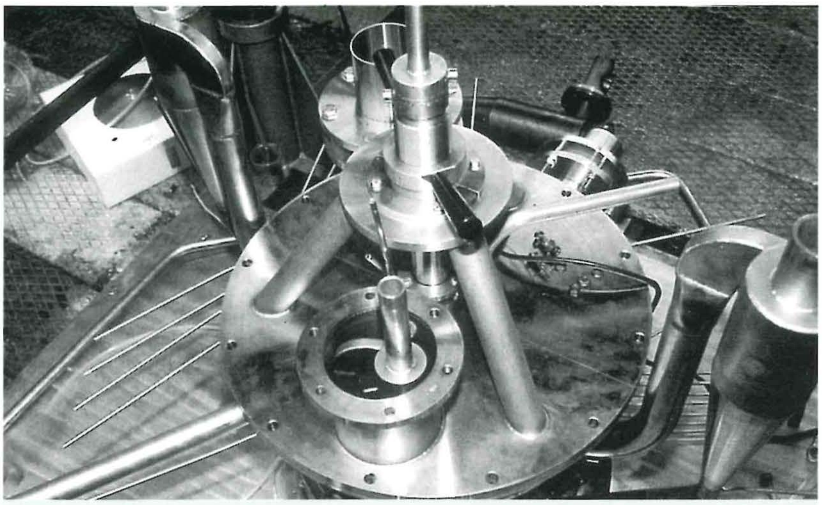
By Professor Van Swaaij and Dr W Prins, Enschede, Netherlands

Twente University

With 10 faculties, 13 degrees at Master of Science level, more than 7000 students and 2500 members of staff, the University of Twente (established in 1961 as a technical university) plays a prominent role in education and research. The emphasis is on a fundamental approach to practical problems. Much attention is then also paid to interaction with businesses and other organisations and to extensive regional, national and international contacts. Advanced studies are incorporated in the Graduate School Twente.

Chemical Reaction Engineering Group

Under the leadership of Professor dr. ir. W P M van Swaaij, research efforts of the Chemical Reaction Engineering group of the Twente University are focused on the development and understanding of new reactors, and subsequent applications of these reactors in the process industry. Specific research areas are gas-liquid (solids) reactors, gas-solids and liquid-solids reactor, and membrane reactors. Various processes are being developed in the field of energy technology, focusing on the generation of clean power with high efficiency. This includes coal gasification, combustion, purification and separation of gases and other thermal processing methods, such as the pyrolysis of biomass materials and plastic wastes.



Close-up of the top section showing the supported and water-cooled biomass feed tube in more detail, and the small cylindrical extension containing the top of the riser system.

Pyrolysis

Gas-solids reactors, such as fluidised bed processes, have been studied for a long time within the Chemical Reaction Engineering group. One direction is also focused on the development of new reactor types. Examples include the Trickle-Flow Reactor, the Floating Bed Reactor, the Membrane Reactor and the Rotating Cone Reactor. For pyrolysis purposes, several projects were aimed at the further development of the rotating cone technology (Prins and co-workers).

Rotating Cone technology

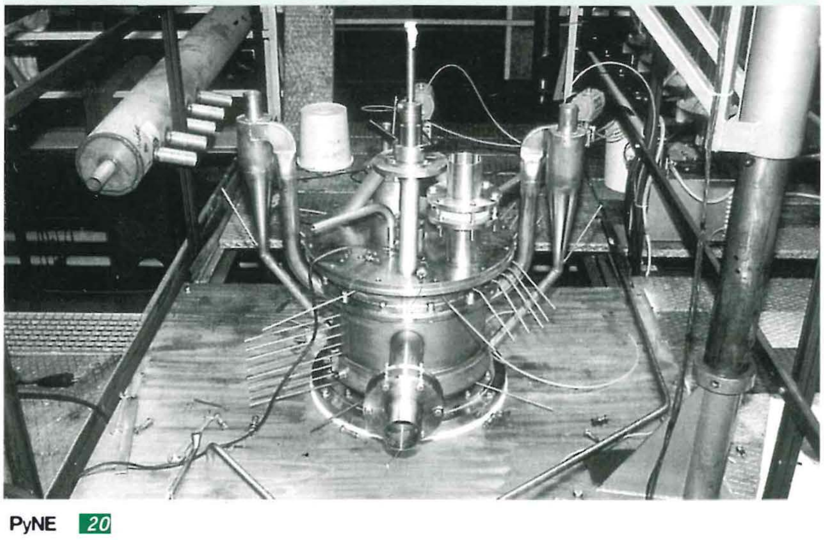
The rotating cone is a novel type of reactor, applicable for fast pyrolysis of solid materials. Solid material that are fed to the bottom of a rotating cone, together with an excess flow of inert (or catalytically active particles), are converted while being transported spirally upwards along the hot cone wall. No carrier gas is needed, which reduces the size and costs of the secondary oil-collection system considerably. Besides, the reactor is very compact and has an extremely high throughput capacity (up to 3 kg solids per second).

Flash pyrolysis of biomass. The technology development for the pyrolysis of biomass in a fully heat-integrated, improved bench-scale unit (10 kg biomass per hour) of the rotating cone reactor (see photographs & diagram on front page) took place in two subsequent European research projects. Recently, the first one together with the University of Aston, the University of Naples and the Wood Institute Hamburg is completed. Current research is concerned with the development and testing of the new concept in the framework of an European Joule-project on catalytic pyrolysis with the afore mentioned partners from the UK, Italy and Germany and partners from Greece and Spain. Special attention will be paid to the (in-bed) catalytic upgrading of the bio-oil. Recently, first experimental results were obtained in this new concept.

Flash pyrolysis of plastic wastes. Another project is aimed at the recycling of plastic waste by flash pyrolysis in another bench-scale unit, also based on the prototype rotating-cone concept by Wagenaar (1994). In this project the 'Back to monomer' concept is experimentally studied on pilot plant scale, and the aim is to produce high value monomers (short heating-up times and rapid quenching). Technical and economical evaluations of the entire process are carried out to guide the development, and indicated that the rotating cone reactor is very competitive with other types of gas-solids reactors (bubbling fluid bed, and riser systems). The work is almost completed and was co-financed by the Ministry of Economic Affairs through the IOP-Recycling programme.

Characterisation of bio-oil. Work is in progress to devise tests for measurement and prediction of bio-oil (thermal) stability.

Total view of the integrated rotating core reactor for flash pyrolysis of biomass. Clearly visible are the two (external) fluid bed cyclones, the vapour outlet, the biomass feed line and the numerous temperature and pressure probes inserted in the system.



VTT Energy *By Yrjo Solantausta, Finland.*

VTT, the Technical Research Centre of Finland, is a government controlled, impartial expert organisation that carries out technical and technoeconomic research and development work. VTT develops technologies both to improve the competitiveness of companies and the basic infrastructure of society, and to foster the creation of new businesses. VTT Energy is one of the nine research institutes of VTT. VTT Energy carries out R&D work on the areas of energy production, energy distribution and energy use. With a staff of 290 the budgeted turnover for 1996 was 150 million FIM. VTT Energy has five research fields: Fuel Production, Energy Production Technologies, Nuclear Energy, Energy Use, and Energy Systems.

Energy Production Technologies has five research groups: Gasification and Advanced Combustion, Process Technology, Analytical Services, Technical Services, and Combustion Research. Within Gasification and Advanced Combustion, among others the following topics are studied: Pressurised gasification and critical technical issues of simplified gasification combined-cycle processes, Atmospheric-pressure gasification for small-scale energy production and for co-combustion in large utility boilers, and fuel characterisation and fundamentals of gasification and hot gas cleaning. The group has an extensive experimental facility at its disposal (examples are shown at http://www.vtt.fi/ene/enetute/GAC/info/info.html). Within Process Technology, among others the following topics are studied: Pyrolysis oil production from biomass: improvement of product quality and reduction of product cost, and Recovery of pulping chemicals, black liquor combustion, alternative conversion processes. The Process Technology Group carries out research related to: Liquid fuel production from biomass, combustion and conversion of spent pulping liquor (black liquor), certain aspects of diesel power-plant processes (alternative fuels, power-plant optimisation), and waste-water evaporation.

In the areas of gasification and fast pyrolysis, Energy Production Technologies is participating to several international collaborative projects for example within EC JOULE/THERMIE and FAIR, and IEA Bioenergy.

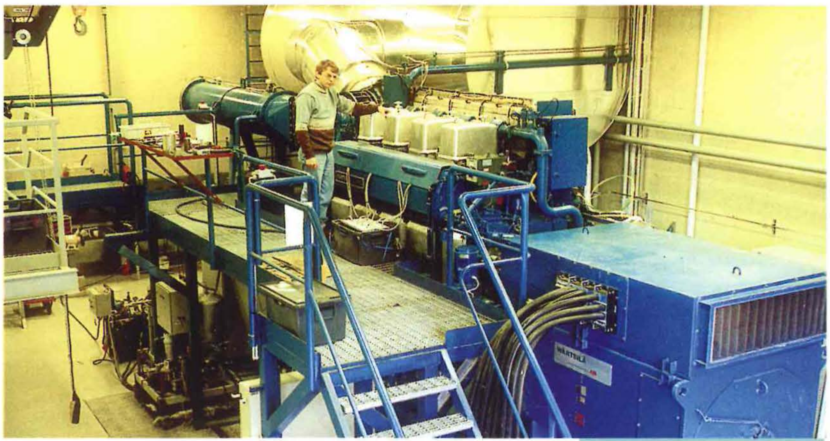
Pyrolysis

Related to fast pyrolysis of biomass, following test facilities and services are being used at VTT Energy: Process Development Unit (PDU)-scale flash pyrolysis unit (20 kg/h) (see Figure 1.), Bench-scale fluidized-bed flash pyrolysis unit with hot filtration (1 kg/h), Bench-scale fluidized-bed flash pyrolysis unit with a catalyst reactor (100 g/h), High-pressure laboratory-scale reactors for liquid-phase processing, Pressurised grid pyrolyser, Pyroprobe - gas chromatograph - atomic emission detector, High-speed diesel engine (60 kW) for alternative liquid fuels, and steady-state simulation of processes with AspenPlus™. In addition, Wärtsilä Diesel has installed a 1.5 MW engine (Figure 2) at the laboratory. Biofuels have also been tested in the engine.

Objectives

The objectives related to bio-fuel R&D work may be summarised as follows:-

- Together with the industry and universities, develop advanced conversion technologies for the market. This is done by studying phenomenon related to these technologies, building bench and PDU-scale facilities, and participating in scaling up of these technologies.
- Review new technologies being developed and report their potential contribution for the energy production system to the authorities and the industry.



▲ *Figure 2.* Wärtsilä Diesel 1.5 mw engine at VTT Energy.

Recent references

More is shown at http://www.vtt.fi/ene/enetute/publications.html.

Sipilä, K., Oasmaa, A., Arpiainen, V., Solantausta, Y., Ahnger, A., Gros, S. & Nyranen, T. Pyrolysis oils for power plants and boilers. Proc. 9th European Bioenergy Conference, Copenhagen 24 - 27 June 1996. In print.

McKeough, P. J., Kurkela, M., Arpiainen, V., Mikkanen, P., Kauppinen, E. & Jokiniemi, J. The release of carbon, sodium and sulphur during rapid pyrolysis of black liquor. Proc. 1995 International Recovery Conference, TAPPI/CPPA. Atlanta: Tappi Press, 1995. P. A217 - A225.

Kurkela, E. Formation and removal of biomass-derived contaminants in fluidized-bed gasification processes. Espoo: VTT Energy, 1996. 47 p. + app. 103 p. (VTT Publ.)

Simell, P.; Kurkela, E.; Stahlberg, P. & Hepola, J. Catalytic hot gas cleaning of gasification gas. Catalysis Today, 1996. Vol. 27, p. 55-

Solantausta, Y., Bridgwater, T. & Beckman, D., The performance and economics of power from biomass. in: Developments in Thermochemical Biomass Conversion, Bridgwater, A, Boocock, D., (eds.). Blackie A&P, Glasgow 1996.

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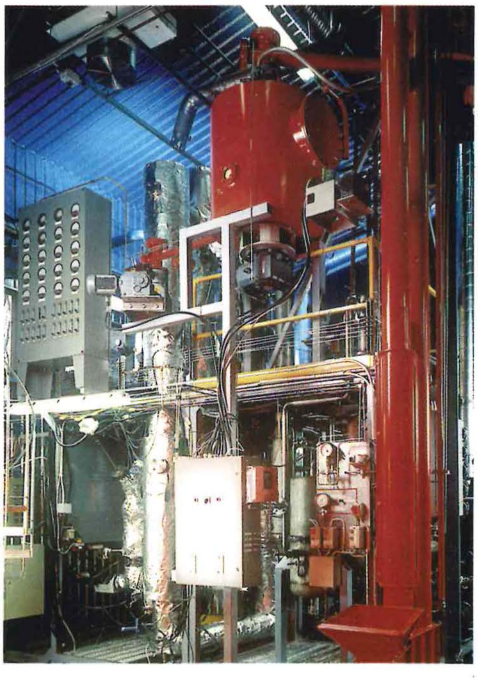


▲ *Figure 1.* Process Development Unit (PDU)-scale flash pyrolysis unit (20kg/h) at VTT Energy.

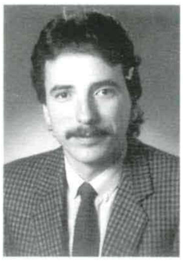
profiles

CONTRIBUTIONS **If you wish to submit a profile of your organisation for publication, please contact Phillipe Girard** *(address at end of newsletter)* **who is the co-ordinator of this task.**

specialist subject groups

Analysis and characterisation

By Dietrich Meier, Group Convenor, Germany.



An important objective of the characterization and analysis group within PyNE is the testing of the inter-laboratory reproducibility of methods used for the characterization of bio-oils. This task is a challenge because of various reasons:

(1) it is the first time that European laboratories, spread all over the continent, are working together on the field of bio-oil analysis,

(2) it is the first time that bio-oils produced in Europe are available in sufficient quantities for a round robin

(3) the possibility exsists to harmonize and adopt methods for analysis before the market introduction of bio-oils.

Participating laboratories (from North to South)

Technical Research Centre of Finland (VTT), Espoo, (FI)
Danish Technological Institute, Aarhus, (DK)
Aston University, Birmingham, (UK)
BFH-Institute for Wood Chemistry, Hamburg, (DE)
CIRAD, Forêt Maison de la Technologie, Montpellier, (FR)
Chemical Process Engineering Research Institute (CPERI), Thessaloniki, (GR)
Instituto Nacional de Engenharia e Technologia Industrial (INETI), Lisbon, (PT)

Two bio-oil samples were distributed. One sample was produced from pine wood at BTG (Biomass Technology Group), Enschede, (NL) with a rotating cone reactor. The other sample was produced also from pine wood at Aston University with a fluidized bed reactor.

The following physico-chemical properties were to be measured:

- viscosity
- water content
- heating value
- elemental analysis (C,H,O,N)
- pH
- solids content
- density

No restriction was placed on the participants as to the methods that should be used to analyse the oils, because each laboratory should gain experience in handling and utilizing this "unknown" bio-oil and subsequently be able to evaluate their methods and procedures. Consequently, various methods were used partly based on "in-house" experience and partly based on ASTM and DIN methods. Not all laboratories provided data on every item but a first evaluation demonstrates there is very little variation in most of the results. However, the largest variation is observed in viscosity and solids content. Therefore, in the near future these items will be discussed in detail and solutions will be proposed. The complete results of the round robin will be published in the final report of the Network.

A resource package for analytical facilities of different laboratories in Europe was established and is available from the convenor of the Analysis and Characterization Group. In total 29 methods were identified which are applicable to the characterization of the liquid and solid products from pyrolysis processes.

An overview of the status of test methods for the determination of properties from fast pyrolysis liquids was presented at the International Conference on "Developments in Thermochemical Biomass Conversion" in Banff, Canada.[1]

To increase the knowledge base for the laboratories involved in bio-oil analysis, a list of pyrolysis products from lignocellulosic materials was provided which can be separated by gas chromatography. The retention times given are obtained using the GC conditions recommended in the first issue of the PyNE Newsletter. This is available on the Internet on the PyNE page at Aston University (http://www.ceac.aston.ac.uk/PyNE/), or a hard copy is available from the co-ordinator.

References

1 Meier, D., A. Oasmaa and G. V. C. Peacocke (1997), Properties of fast pyrolysis liquids: status of test methods In: Developments in Thermochemical Biomass Conversion (eds. A.V. Bridgwater and D.G.B. Boocock), Chapman & Hall, London, 391-408.

Calls for proposals

FAIR

Exploratory awards for SME's

Closing Date:		11-06-97
Contact:	Fax:	+32 2 296 4322
OJ Reference:		17.12.1996/C381

Co-operative research projects for SME's

Closing Date:		08-04-98
Contact:	Fax:	+32 2 296 4322
OJ Reference:		17.12.1996/C381

FAIR programme areas, 3, 4, 5

Closing Date:		15.09.97
Contact:	Fax:	+32 2 296 4322
OJ Reference:		15.06.1997

JOULE

Joule programme areas
2: 2.1
3: 3.1, 3.2, 3.3, 3.4, 3.5, 3.7, 3.8
4: 4.1, (topic 4.1.A.1)

Closing Date:		06-05-97 (12:00 hrs local time)
Contact:	Fax:	+32 2 296 6882
OJ Reference:		17.01.1997/C18

Research Training Grants Area 1, 2, 3, 4

Closing Date:		01-07-98
Contact:	Fax:	+32 2 295 0656 (DGXII)
	Fax:	+32 2 295 0577 (DGXVII)
	Email:	info@dg17.cec.be
OJ Reference:		15.6.1996/C171

Demonstration

Closing Date:	17-12-97	
Contact:	Fax:	+32 2 295 0656 (DGXII)
OJ Reference:		15.12.1994/C357

TRAINING AND MOBILITY OF RESEARCHERS (TMR)

Access to Large-scale facilities

Closing Date:		16-06-97
Estimated Date of selection:		15-12-97
Contact:	Email:	tmr-info@dg12.cec.be
OJ Reference:		17.03.1997

Research Training Grants

Closing Dates:		16-06-97 15-12-97
Estimated date of selection:		02-12-97 15-05-98
Contact:	Email:	tmr-grants@dg12.cec.be
OJ References:		17.03.1997 15.09.1997

Euroconferences, Summer School and Practical Training Courses

Closing Dates:		30-09-97 31-03-98
Estimated date of selection:		31-03-98 30-09-98
Contact:	Email:	tmr-info@dg12.cec.be
OJ References:		16.06.1997 15.12.1997

ENVIRONMENT AND CLIMATE

SME awards

Closing Date: 11-06-97 (17:00 hrs local time in Brussels)

Contact:	Fax:	+32 2 296 30 24
	Email:	environ-infodesk@dg12.cec.be
OJ Reference:		17.12.96/C381

Training Grants

Closing Dates:		20-08-97 20-03-98 20-08-98
Contact:	Fax:	+32 2 296 30 24
	Email:	angel.arribas@dg12.cec.be
OJ Reference:		15.12.1995/C337

Further information on new calls for proposals from national and international organisations are provided. Information for inclusion should be sent to Claire Humphreys, (address on front page).

Calls for proposals

book reviews continued...

Circulating Fluidized Bed Boilers Design & Operations

P Basu and S A Fraser
Stoneham 1991, 350 pp.
Butterworth-Heinemann, 80 Montvale Avenue,
Stoneham, MA 02180 USA

Circulating Fluidized Bed (CFB) plants are more and more utilised in thermochemical conversion of biomass. This book is designed to provide practising engineers with insight into the design and operation of circulating fluidized bed plants. Through a combination of theoretical concepts and practical experience, this book gives the reader a basic understanding of the many aspects of this subject. The book can provide engineers involved in steam generation or in the manufacture of circulating fluidized bed boilers, an appreciation of the process, its capabilities and its limitations.

The book is comprised of 10 chapters and 4 appendices, including 8 tables that are useful for design of circulating fluidized bed boilers and other fluidized bed equipment.

The first chapter introduces readers to circulating fluidized bed boilers and compares this technology with others. Chapters 2 to 5 cover the basics of hydrodynamics, heat transfer, combustion, and gaseous emission, with special emphasis on their application in circulating fluidized bed boilers. Chapter 6 pulls together information in other chapters to a common approach to the design of this type of boiler. The relevance of design and feed-stock parameters to the operation of a circulating fluidized bed boiler is also discussed in this chapter.

Designs of mechanical components, including cyclones, air distributor grids, and solid recycle systems, are discussed in Chapters 7 and 8. Disposal of solid wastes is a major facet of the operation of a circulating fluidized bed power plant and is discussed in Chapter 9. Circulating fluidized bed boilers present some special problems with construction materials, which are presented in Chapter 10 on material issues. Appendix I discusses physical characteristics of solids relevant to fluidisation. The stoichiometric calculations needed for the heat and mass balance of the combustion reaction are presented in Appendix II.

Renewable Energy Systems in South East Asia.

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The Southeast Asia/Pacific Rim region is pioneering the application and trade of non-conventional energy equipment. In Renewable Energy Systems in Southeast Asia, Dr Joanta Green surveys the market prospects and technology of non-conventional power-generating and transforming equipment in that region.

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Editorial

The PyNE newsletter is published by the Energy Research Group, Aston University, UK and is sponsored by the EC AIR Programme in DGXII, Brussels.

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