PyNe

The Evolution of Energy – Biomass to BioOil

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DYNAM🌑TIVE

PyNe contents

BioOil

BioOil is not an oil, or a hydrocarbon, as its designation may suggest, and can be confusing for some. BioOil (BO) is the liquid form of biomass waste produced by fast pyrolysis. Pyrolysis is the high temperature, oxygen-free process wherein biomass is decomposed into hundreds of organic compounds and fragments. When cooled, we are left with a liquid (BO), a solid (Char), and some non-condensable combustible gas used to sustain the pyrolysis process. Typically the ratio of BO / Char is 4/1, by weight. The molecular composition and heat value of the BO resemble the feedstock from which it originated. 50% of BO remains as oxygen. In fast pyrolysis, the feedstock is utilised 100% – an utilisation rarely met by other fuel producing processes, like BTL ethanol.

Dynamotive BioOil Applications and Commercial Use

Dynamotive now produces BO in commercial quantities, with MSDS, and handles and transports it to flammable liquid standards.

The commercial use of char is being explored. Dynamotive finds char an excellent fuel additive when mixed with the BO and now markets the biofuel mix as Intermediate BioOil (IB). Grinding the char to an average 10 micron particle size provides the mix with considerable stability (see figure 1 opposite).

Industrial utilisation of BO is in rapid progress. Dynamotive is a leader, demonstrating BO and IB as fuels in large scale test burns in heaters, boilers, metallurgical furnaces and kilns. BO also drives an Orenda type turbine in Dynamotive's 2.5 MW power generation plant at West Lorne in Ontario. These large scale field test burns clearly confirm BO and IB can be handled like a conventional fuel and are excellent greenhouse neutral fossil fuel substitutes. They are sulfur free, ignite easily and burn to completion with low CO and NO_x emissions. All BO used for these tests was produced by Dynamotive's 100 tpd (tonnes of feedstock per day) hardwood BTL plant at West Lorne. Our next plant, a 200 tpd unit installed at Guelph, Ontario, is nearly ready to go on stream producing BO from waste wood building materials.

BO moves along a commercial "value train" from harvest through processing to off take of products and end use.

At the front, feedstock supply must be secured in competition with a growing number of new users of plant residues. Some residues are already valuable commodities and cultivation of fast growing crops may be needed to secure supply - without interfering in the area of food crop usage. Dynamotive is not a single-crop user.

The end use of BO is not limited to fuel combustion and power generation.

Fast Pyrolysis on a Commercial Scale

While Dynamotive's technological advancements started at bench scale, the break through came with the installation and operation of its 2 tpd and 15 tpd pilot plants. Today, Dynamotive markets its 200 tpd units as standard. Soon, there will be three plants in operation.

Dynamotive has tested and found over 120 different plant species useful for BO production. However, in its development program, Dynamotive experimented mainly with softwood residue as this was in abundance locally and the closest available geographically. Brazilian bagasse was also processed with BO yields in excess of 68%. As a result, Dynamotive produced over 130 tonnes of BO and established the largest storage of BO in the world. It verified the single phase stability of BO extends well beyond six months. A good deal of this BO was used as fuel in combustion and gasifier tests or was provided to research organisations around the world for their studies.

BioOil Utilisation by Demonstration

Burn tests have been Dynamotive's most immediate and successful route to demonstrate BO as a new and "green" substitute for fossil fuel on an industrial scale. Two to twenty tonnes of BO, depending on application and test duration, were typically fired. The basic approach was to use the existing fuel train from fuel pump to burner station and nozzle with fewest modifications. Hence, to avoid fuel conversions, all trials were made on oil fired units firing either diesel oil, fuel #2 or #6 (bunker C) matching the regular fuel heat input. In almost all cases the existing fuel lines were in carbon steel and the tests were kept short to minimise corrosive damage. We often found BO would form a film inside the carbon steel piping which necessitated a cleaning, in some cases fuel filters could plug up. Upon completing a test, the piping was flushed with alcohol as this was found to be the best cleaning agent. The spent alcohol was simply fired.

The lower heat value of BO meant the fuel pumps had to handle almost twice their usual volume, and a much more viscous liquid. Yet the pump margins were regularly adequate to meet the conditions. Existing heating and filtering sets were used as installed or bypassed. In some instances, for pressure control, it was necessary to install a larger nozzle.

Atomisation could be mechanical, air or steam atomised and worked in all cases with no particular pressure differential control problems. Only the ratios of fuel flow / combustion air needed adjustment. This was done by reset, mechanically or electronically. (Note that the air flow requirement is fairly constant with heat input and needs no major adjustment due to the fuel change, but only for excess air capability, if required.)
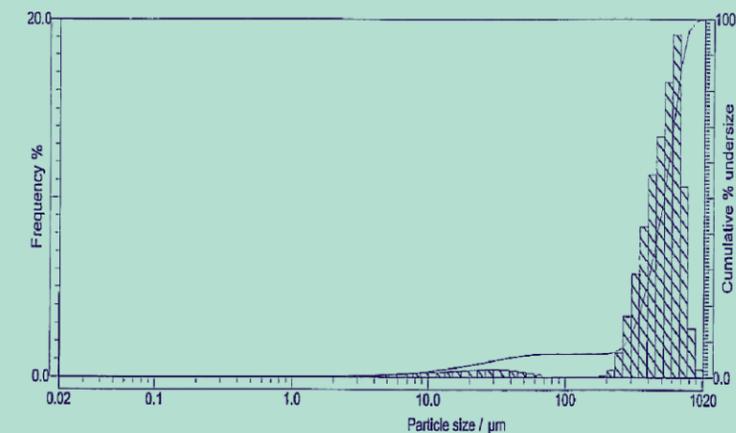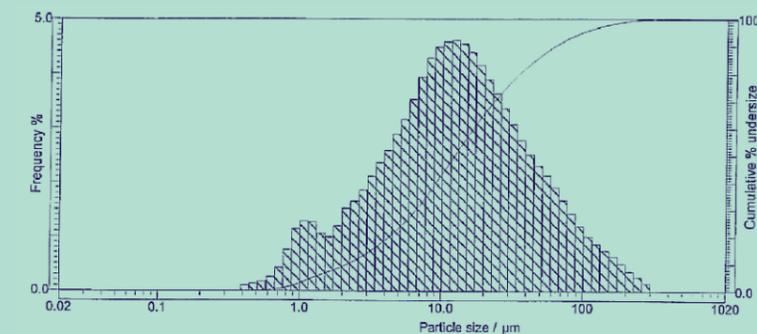

Figure 1. Particle size distributions of char in bio-oil.

Six major fuel trials were conducted successfully under these conditions – in and outdoors and in Canadian winter conditions. Test objectives to measure NOx, CO and particulate matter were not always met. When measuring NOx it was found to be 20-30% lower than the fuel (e.g. fuel #2) normally fired. CO emission could be single ppm digits while particulate matter was at the lowest level on the scale with no visible emission from the stack. Standing downwind from the stack, there was no trace of smell from the BO being fired.

The BO would be hauled to the test site in $1m^3$ totes or in tanker trucks. In summer, the BO was transported at ambient temperature. In winter, it was loaded preheated to 35°C into insulated tanker trucks. Viscosity is the major variable in BO handling and testing. A minimum of 15°C is required for general storage and handling, with preheat to about 30°C at the burner tip. At 0°C the BO would be so thick it hardly flows. Our field tests will soon expand to include firing of IB.
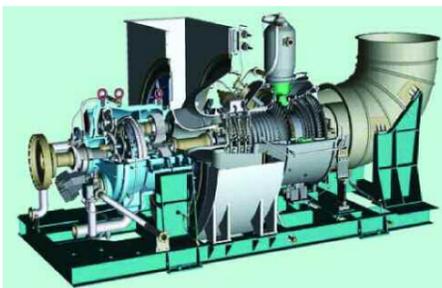
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BO testing in gasification has shown promising syngas composition results that will be confirmed and optimised. Producing syngas from plant waste is greatly facilitated by having it in liquid form to be pumped into the pressurised gasifier. Coupling fast pyrolysis to gasification will be simple, as well proven technologies can be applied. Using IB with 20% char as feed to the gasifier raises the carbon content and thereby the HHV to about 8500 BTU/lb. Gasification is of special interest as it opens the routes to synthetic "green" methanol or diesel oil via syngas followed by catalytic processes like Fisher Tropsch or Bergius.

Emulsification of BO in diesel has been well demonstrated and operation with emulsions in diesel engines has been tried. BO purity is critical and solids and char contaminants must be controlled. The acidity of BO demands fuel train and injector modifications to the ordinary diesel engine. Low concentration emulsions of BO in diesel might facilitate these modifications as well as lubrication and still bring about a quantum of "green" fuel substitution.

As we learn more about the constituents of BO and their availability, it opens up options for their distillation and extraction. In this endeavour, Dynamotive is collaborating with renowned research institutions like Institute Française du Petrol. In addition, an extractive like hydroxyacetaldehyde has had considerable commercial value in the food flavouring industry. It is present in Dynamotive BO in 4-6% by weight and is regularly shipped to customers for extraction.

2.5 MW Commercial Gas Turbine Designed and Operating on BioOil

The Orenda modified OGT2500 gas turbine (see Figures 2 and 3) installed at the cogeneration facility of Dynamotive's Demonstration Plant in Ontario generates up to 2500 kW of electricity operating on BO derived from wood waste (see Table 2). Extensive testing of the turbine has confirmed it stabilises quickly following rapid load changes, with impressive turndown ratio between idling and maximum stable operation on this fuel and with emissions well below the environmental limits of distillate and crude oil fuels (Table 1).

The gas turbine modifications include hot section redesign, atomised fuel injection, adaptive controls and hot section online cleaning. On natural gas fuel, the OGT2500 is rated at 2670 kW base load output at 15ºC ISO conditions with a heat rate of 12,780 Btu/kWh (26.7% efficiency). It has a 12.0 to 1 pressure ratio, 33.1 lb/sec mass flow and 860ºF exhaust temperature. On BO fuel this modified gas turbine rates at 2500 kW base load.

Figure 2: OGT 2500 gas turbine.

Gas Turbine Considerations

With the switching of fuels, the high viscosity of BO was a concern. It required preheating to enhance its handling, injection and combustion properties. BO also tends to produce deposits on hot section parts that can lead to hot corrosion or severely reduce turbine blade efficiencies. Such deposits can be controlled by online cleaning, which can become a continuing requirement. Fuel nozzle design was critical as the nozzles must be able to operate in a dual fuel mode, distillate and BO, and at the same time atomise and inject the fuel droplets into the combustors. In this BO application, the fuel nozzle has three channels to handle distillate, BO and gas turbine compressor bleed air for fuel atomisation. An electric motor powered compressor delivers 250 kPa for atomisation and injection. The atomiser design included margins in BO viscosity and droplet sizes, nozzle plugging and particulates in the fuel. Combustion liners were modified. Cooling air injection points were modified at the front section of the combustor to keep wall temperatures below 800ºC.

Combustion System

Basic goals of the liner design changes were to control NOx and CO emissions and complete combustion of the viscous fuel droplets, which could be larger than for a distillate fuel. Impingement of liquid droplets on turbine blades and vanes must be avoided as it can cause local overheat and stress risers. The OGT2500 hot section was redesigned to enable replacement of all turbine vanes and blades onsite, reducing service cost and increasing availability. An online hot section cleaning with crushed nut shells was installed to control build-up of deposits on combustion liner and turbine airfoil surfaces and to clean and polish the hot gas path surfaces.

Figure 3: The Orenda OGT 2500 Turbo-generator installation at the Dynamotive West Lorne co-gen plant.

Table 1. Turbine test performance on BioOil.

Test Performance	BioOil	Distillate
Fuel flow (per hour)	1883 litres	1071 liters
Electric generator output	2510 kW	2510 kW
Inlet air temperature	-2.1ºC	-2.8ºC
Exhaust gas temperature	417ºC	403ºC
NOx emissions	58 ppm	321 ppm
SOx emissions	2 ppm	7 ppm
CO emissions	48.7 ppm	1.0 ppm

Table 2. Fuel properties.

Fuel Properties	BioOil	Distillate
LHV heat rate (MJ per kg)	15-17	42-43 M
Relative density (kg per liter)	1.2-1.3	0.82-0.86
Kinematic viscosity (cST)	17-48	3-6
Flash point (ºC)	58	74
Carbon (weight %)	42.0	84-87
Hydrogen (weight %)	7.3	13-16
Nitrogen (weight %)	0.06	0.05
Oxygen (weight %)	44.7	–
Water (weight %)	15-21	200
Sulfur (weight %)	0.02	0.4

Fuel Treatment

A dedicated fuel handling module for fuel preheating and processing of the BO was installed. It contains holding tanks for BO (with heater and agitator), distillate and ethanol (for purging), associated pumps, filters, fuel flow control and mixing valves. Steam heating of distillate and BO to 95ºC is installed at the inlet to the high pressure fuel pumps to the gas turbine. The fuel handling control system integrates fuel supply and gas turbine operation including emergency procedures.

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Renewable Adhesives for Wood Composites

By Eleftheria Athanassiadou, Chimar Hellas, Greece

Chimar Hellas S.A.

Profile

CHIMAR HELLAS S.A. is an innovating technology provider for the resin and wood-based panel industries (particleboards, fibreboards, plywood, oriented strand boards, laminating papers). It develops in-house and licenses know-how for the production of formaldehyde, urea-formaldehyde pre-condensate (UFC), formaldehyde-based resins and resin additives as well as their application in the manufacturing of wood-based panels. It also develops processes that enhance the productivity and profitability of manufacturing of resins and wood panels, and is active in the engineering works for the construction, start up and operation of respective resin and additive plants. CHIMAR continuously focuses on "green" chemicals and technologies, fulfilling eco-efficiency principles.

Renewable Adhesives For Wood Composites

Synthetic resins like urea-formaldehyde (UF), phenol-formaldehyde (PF), and melamine-formaldehyde (MF) are commonly applied in the production of composite wood panels (wood-based panels), to bind the wood elements together and form the final panel products. These resins are synthesised from petroleum and natural gas derived chemicals and therefore their prices are directly dependent on the fluctuation of oil prices. Moreover, given the finite nature of the oil deposits, the long-term availability of petroleum-derived products is not guaranteed.

The use of wood panel products contributes to more efficient forest utilisation and thus provides a cost effective solution to related environmental problems. To utilise large quantities of forest residues for conversion into low cost panel products, it is necessary to develop less expensive adhesives with secured availability, in order to gain meaningful advantage. Adhesives from renewable (non-petroleum) raw materials have a significant role to play in this regard. The promising renewable resin contenders should match the reactivity, applicability, bonding performance and cost requirements of the synthetic resins and outperform them in environmental acceptability and safety of use.

Large quantities of renewable biomass materials and natural derivatives are available, which can be converted into adhesives for panel products. The use of biomass as a source of chemicals and energy enables closed-cycle material changes and contributes to the efforts to reduce the atmospheric CO2 emissions worldwide.

In this framework, CHIMAR HELLAS has worked extensively on developing resins from renewable resources for application in wood-based panel production, aiming for:

- Environmentally friendly adhesives for the wood panel sector ("natural binders")

- Adhesive resins that contribute to the reduction of panel formaldehyde emissions

- High performance, low cost resin products for the wood panel manufacturers and the panel end users: the sector as a whole.

The know-how and experience gained focuses on resins derived from natural products or by-products. An extensive but not exhaustive list includes: tannin, lignin from paper production, pulping spent liquor, pyrolysis oil (bio-oil), extraction or liquefaction products of agricultural and forestry residues (i.e. cashew nut shell liquid (CNSL), liquefied wood, liquefied olive stones), soy. The above resins developed by CHIMAR have been tested in the production of panels at laboratory scale, pilot scale and the most successful ones at industrial scale, in direct comparison with the commercial resins that are commonly applied.

Highlights of Achievements

Phenol-formaldehyde resins were produced by substituting up to 50% of the phenol needed in the formulation with biomass pyrolysis oils (bio-oils) and by modifying the resin synthesis procedure. Glue mixes containing these resins together with/without using CHIMAR proprietary activator technologies also based on renewable resources, were successfully applied in large-scale production of oriented strand boards and plywood panels. The resin production sequence was adapted to accommodate for the difference in the field of resin application. The use of bio-oil resin systems has provided reactivity and performance equal to the non-modified PF resin systems in both products. Such systems are currently being used commercially in North America.

Furthermore, tannin adhesives for particleboards were developed and applied commercially. In these systems, the tannin represents almost 90% of the adhesive used in the core phase of three-layer particleboard, while the rest components are urea and formaldehyde. Tannin is also sometimes added to the surface layers of the particleboards together with melamine-urea-phenol-formaldehyde resin.
It was also proven that phenol-tannin-formaldehyde (PTF) resole resins prepared by CHIMAR with 20% substitution of the phenol with tannin provide plywood panels with acceptable performance at industrial scale.

The above renewable materials offer cost savings to the resin and panel manufacturers and to the panel consumers. They also promote the sustainability of the same industries and respective products. Most importantly, they are in line with the efforts to prepare natural resins and environmentally friendly products. Further increase in the substitution level is envisaged, with the aim to achieve a higher reduction of the resin cost and increase the positive environmental impact.

The renewable adhesive systems developed by CHIMAR contribute to the above positive effects and pave the way for the development and commercial adoption of natural resins for wood products.

Figure 1. Plywood production.

Figure 2. Particleboard, MDF, OSB (Source: EPF website).

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Time Dependant Calorific Value and Oxygen Demand of Volatiles – Including Tars

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Introduction

Recent goals to significantly reduce green house gases such as carbon dioxide, can only be achieved by substituting limited fossil fuels with alternative sources of energy such as biomass and by optimising industrial processes regarding emissions. In Austria, the proportion of biomass and other renewable energy sources of the primary energy was 11% (3.3*106 t) in 2001 [1] and is on an upward trend. More than two thirds of this renewable energy are utilised in small scale heating installations and combined heat and power plants. In 2006 the amount of newly installed pellets heating units exceeded the number of new oil fired furnaces for household heating units. Therefore investigations of the calorific value and the oxygen demand of biomass during thermal conversion, especially of wood pellets, are of great importance if the heat is to be used efficiently and the emissions reduced.

When biomass and other solid fuels are used for energy production in thermal processes the particles run through the following steps:

- Drying

- Pyrolysis

- Gasification

- Combustion

Whereby pyrolysis – the process in which the volatiles are set free – plays a key role, because up to 85 wt.% [2] can be released in the form of volatiles. Depending on the process conditions (e.g. temperature, atmosphere) and on the particle properties (e.g. moisture, geometry, composition) the volatiles contain more or less tars (higher molecular hydro-carbons), which can cause operational problems if they condense.

Measuring Basics

Analysing tars for example with gas chromatography to calculate the calorific value and the oxygen demand dependent on time is not possible. This can be done with the developed mobile differential scanning calorimeter (DSC), which burns all volatiles – including tars – on a catalyst surface. The measured temperature change on the catalyst, together with the detected transfer behaviour of the DSC and the mass loss of the solid fuel, gives a direct bearing of the calorific value. By detecting the oxygen in the flue gas and with the known air feed to the DSC, the time dependent oxygen demand for the total combustion of all formed volatiles can be measured. A scheme of the DSC can be seen in the figure 1.

The heat exchanger and the catalyst part are preheated to the starting temperature of the catalyst in order to minimise temperature losses. This is important to get a nearly linear bearing of measured temperature and heat of reaction during measurements.
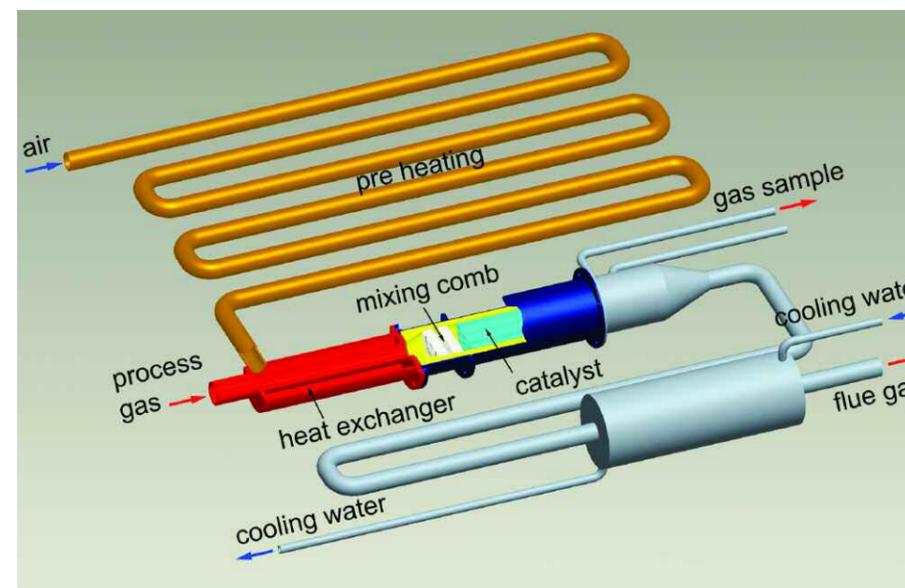
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Figure 1: Scheme of the DSC.

Singe Spruce Wood Pellets Investigations

As mentioned above the usage of pellets in small scale combustion units has risen significantly in Austria. Furthermore the size of solid fuels has a great influence on the formation of the burnable volatiles [3]. Figure 2 shows the result of the calorific value and the oxygen demand of three different pellet sizes (6mm diameter and 25mm length and 10mm diameter and 20mm and 25mm length).
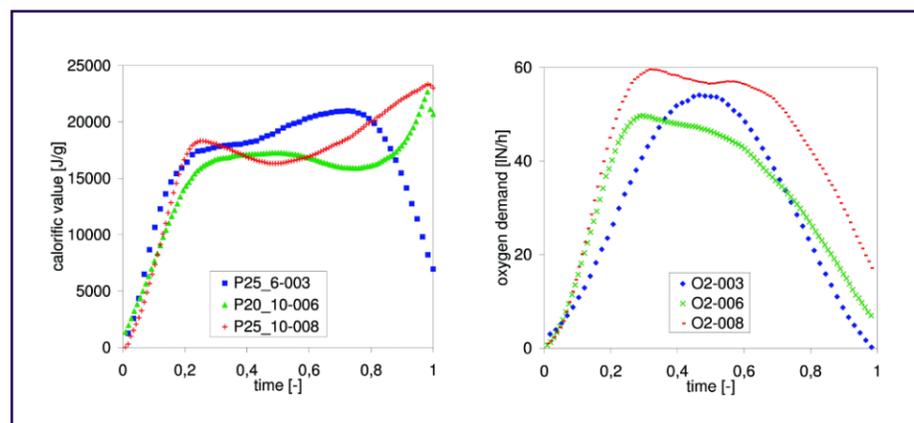

Figure 2: Calorific value and oxygen demand of volatiles from spruce wood pellets versus dimensionless time with 6mm diameter and 25mm (P25_6-003) length and with 10mm diameter and 20mm (P20_10-006), 25mm (P25_10-008) length at flash pyrolysis conditions (825°C, purge gas: nitrogen).

The calorific value of the 6 mm pellet shows a faster increase due to the larger heating rate caused by the larger specific outer surface. The bigger pellets (10 mm diameter) show a similar behaviour during the first 16 percent of pyrolysis time. However, the longer pellet shows a distinctive maximum at the end of the first increase due to an absolute greater amount of pyrolysis gases. The larger the pellets, the more distinctive the maximum reached at the end of pyrolysis time. The increase to the final maximum starts earlier in case of the longer pellets and hence the mass amount of volatiles with a higher calorific value is bigger. The amount of the 6 mm diameter pellets with a calorific value greater than 18,000 J/g is 46 wt.% and for the biggest pellets 37 wt.%. The share of the pellets with 10mm diameter and 20mm length however is only 11 wt.%. The maximum of the 6mm diameter pellets is lower and no maximum can be detected after the first rise. This is due to the heating rate and the shorter volatilisation time. In the case of the bigger pellets, the formed volatiles have to flow through the formed hot ash and carbon framework, hence the formed tars have to undergo secondary crack reactions which cause the higher calorific value at the end.

The reason that the 6 mm diameter pellets have a heating value above 18 kJ/g is the pathway of the pyrolysis products during the pelletisation process. The pellet production process creates a shallow high temperature zone on the outer surface of the particles. Hence the internal pores are closed and the volatiles formed are more likely to move along the length of the pellets. The length of the pellets

therefore has a significant influence on the residence period of the volatiles formed within the particle and hence on the secondary cracking reactions.

The time dependant oxygen demand of the 6 mm diameter pellets rises to a maximum and decreases to zero immediately after the maximum was reached. The 10 mm diameter pellets show a shoulder after the first maximum before decreasing to zero at the end of the pyrolysis time. Generally a trend can be observed of higher maxima at the beginning and longer shoulders as the pellet length

Conclusions

The bigger pellets show a distinctive maximum especially at the end of the pyrolysis time, whereby the smaller ones behave differently. The maximum at the end is not so distinctive. The lower share of volatiles of the shortest pellets investigated – with a calorific value above 18,000 J/g – is caused by the shorter longest degasification route. The pyrolysis gases are more likely to stream along the pellet than radially. Therefore the time for cracking reactions on the hot ash and carbon framework is much shorter for the pellets with 20 mm length. In connection with this finding it can be concluded that the production and transport of pellets should be optimised in order not to break pellets into small particles. By using longer pellets and assuming that the duration of each pellet in the hot oven atmosphere is long enough for a sufficient conversion, it is easier to establish a constant heat release. This on the other hand makes it easier to efficiently use the formed heat and hence to operate the oven.

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PyNe Workshop Report

By Emily Wakefield, Aston University, UK

ASTON UNIVERSITY
IN THE HEART OF BIRMINGHAM

Biorefinery Case Studies Update

A PyNe meeting was held on the 21st March in Salzburg. The workshop began with an update on progress in biorefinery case studies lead by Doug Elliott. A template for mass and energy balances is to be sent to all PyNe members for completion to carry out a technical assessment of biorefineries. It was agreed that PNNL, USA would work on a petroleum based biorefinery, Aston University, UK and IWC, Germany would work together on a specialist chemicals biorefinery and FZK, Germany and BTG, Netherlands would look at a biofuels based biorefinery. Charcoal and known case studies will be used to prove the template. Results from this task will be reported at a later date.

Waste Wood Definition

Max Lauer explained how the wood processing industry works and what by-products are produced. In sawmills cylindrical logs are sawn to flat planks, boards, strips etc. The by-products are sawdust, end cuttings and those elements of the cylindrical log that are outside the square edged products. In upgrading planks, boards etc. such as by shaving, format cutting, grinding etc., additional by-products are produced including shavings, sawdust and dust (from grinding). All byproducts except fine particles such as sawdust and shavings are usually chipped for sale to the wood consuming industries referred to below.

A log in the sawmill usually produces 60 to 70 % of useful timber as planks and boards etc., 20 to 30 % as wood chips and about 10 % as sawdust. The following by-products are therefore produced:

• Wood chips from sawmills, furniture making, etc.

• Sawdust from sawmills, furniture making etc

• Wood shavings

• Grinding dust

Other wood consuming industries that convert wood into non wood products do not produce any of these wastes and the following are examples:

• pulp and paper production

• cardboard production

• chipboard production

• pellet production

• firewood production

These industries will compete with the energy sector for supplies of wood and wood processing by-products.

Lignin Pyrolysis Round Robin Update

A final report on the lignin pyrolysis Round Robin will be compiled when all results have been received. Some results were ready to be discussed.The sources of lignin were Etek Etanolteknik AB in Sweden who supplied a mild acid hydrolysis lignin and GRANIT Asian Lignin Manufacturing (ALM) who supplied a sulphur-free pulping lignin. Paul de Wild of ECN, Netherlands presented their preliminary results on pyrolysis lignin, which are summarised overleaf.

Figure 1: PyNe workshop, Salzburg.

Preliminary Results of Lignin Pyrolysis at ECN

By Paul de Wild

Pretreatment

The size distribution of the ETEK lignin was inhomogeneous and varied from powder to large lumps. It was pretreated by sieving it into 1-4mm sieve fraction and drying at 60°C for several days. The GRANIT lignin was homogenous in particle size and was slurried with EtOH and evaporated at 60°C for several days in the air. The resulting cake was crushed and sieved into a 1-4mm sieve fraction.

Experimental Conditions

The conditions used to pyrolyse the lignin samples were as follows:

- A lab-scale atmospheric pressure bubbling fluidised bed unit was used with a capacity of max 1 kg/hr. (See Figure 2) Fluidisation of the heated sand-bed (0.25mm) was with preheated Ar.

- The feeding mechanism was batch mode, rapid screw-feeding of approx 100g lignin with N_2-cooled screw. (See Figure 3)

- The operating temperature was 500°C

- Short vapour residence times (< 1 second), solid residence time (minutes)

- Fractionated sampling of reaction water and organic condensables, off-line analysis by Karl-Fischer, GC/FID and GC/MS (See Figure 4)

- Continuous monitoring of 'permanent' gases (Ar, CO, CO_2, H_2, CH_4), sampling of entrained char via cyclone and particle filter.

Figure 2: The pyrolysis rig at ECN.

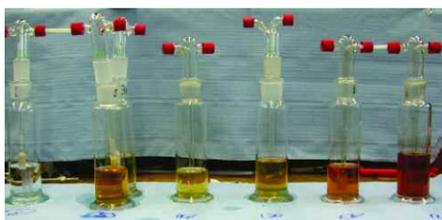*Figure 3: The feeding system for the pyrolysis rig at ECN.*

Figure 4: Sampling of reaction water and organic condensables according to the European Technical Specification for tar measurement in biomass gasification.
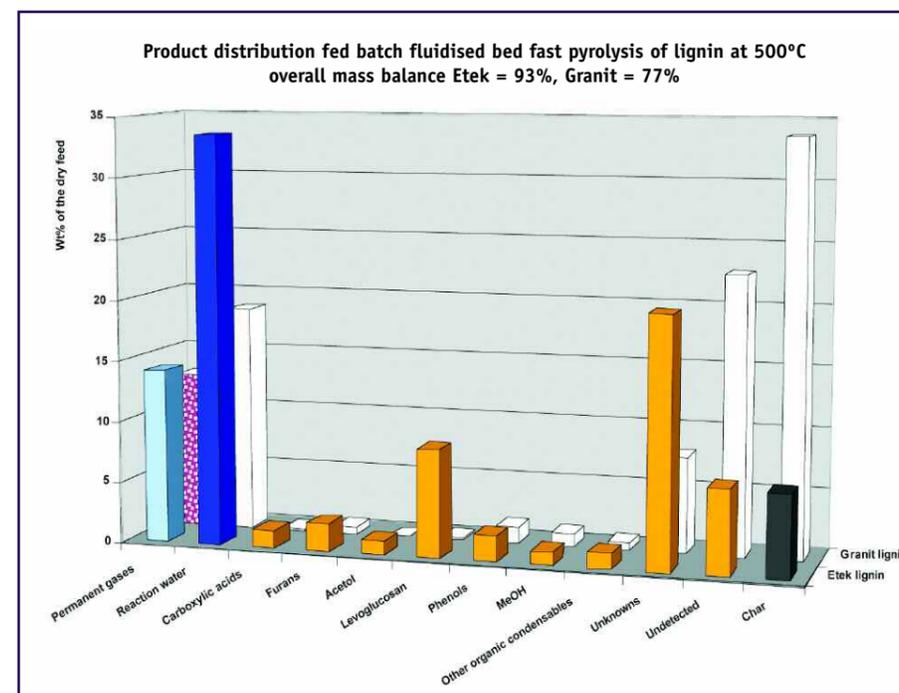

Figure 5: Gas washing train for collecting liquid products.

Figure 6: Distribution of lignin degradation products (detected by gas chromatography).

Product distribution fed batch fluidised bed fast pyrolysis of lignin at 500°C overall mass balance Etek = 93%, Granit = 77%

Figures 7 A-D: Bed defluidisation due to agglomeration.

Results

The Etek lignin was found to have a very high cellulose content and was not really a true lignin as it reacted as cellulose would in tests. TGA results showed the ETEk lignin was much more reactive than the GRANIT lignin.

The distribution of lignin degradation products is shown in Figure 5 below. The char yields were much higher for the GRANIT lignin, which could be a result of partially reacted lignin due to the defluidisation of the fluid bed. There was a large proportion of (hemi)cellulose degradation products such as levoglucosan from the ETEK lignin.

Major defluidisation problems were experienced in the fluidised bed following feeding of the Granit lignin due to agglomeration of the bed sand and lignin. (See Figures 7 a-d). A better/ faster degradation of the lignin might have been achieved by heating the bed to 600-700 degrees to prevent the temperature drop experienced on feeding the lignin. A single batch feed process was used and continuous feeding was not attempted due to the small amount of material available.

It was not possible to perform viscosity, pH etc test on the bio-oil as the amount of bio-oil collected in the tar pot was too small to analyse.
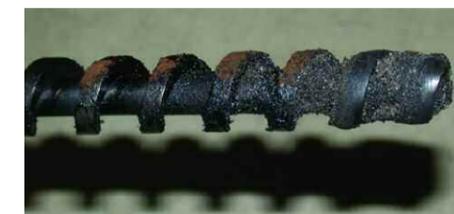
It was agreed within the group that it would be helpful to obtain further samples of lignin for comparison with the samples currently being tested and this will be investigated further.

Concluding Session

The afternoon session consisted of a workshop on fast pyrolysis barriers, led by Tony Bridgwater. Mr Tumiatti of SEA Marconi, Italy, then presented the Haloclean® Bioenergy project for pyrolysis liquid for power generation, which is being carried out in conjunction with Forschungszentrum Karlsruhe, Germany.

Mr Axel Winter presented the SamoaFiber biofuel concept. SamoaFiber (Gynerium Sagitattum) is a member of the grass family which grows in the wild in Peru and can be grown on plantations. This energy crop is being used in a fast pyrolysis process to produce bio-oil.

Finally Cordner Peacocke presented the slow pyrolysis demonstration plant of BEST Energies, Australia, on behalf of Adriana Downie, which is a 300kg/hr unit. This is used to produce charcoal for carbon sequestration and fuel gas for power generation.

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