Fast Pyrolysis Bio-Oil Technology and Production

Your Sustainable Alternative
Fast Pyrolysis Bio-Oil Technology and Production

Gerhard Muggen (BTG-BTL)
BioWKK conferentie “Groene stoom voor de industrie”
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1. Pyrolysis Technology
1.1: What is pyrolysis?

➢ Thermal cracking of organic material in the absence of oxygen
  ▪ Main Product = Liquid Bio-oil
  ▪ Process conditions:
    T = 400 - 600 °C
    P = atmospheric
  ▪ By products:
    Heat (Steam)
    Power (Electricity)

➢ Works with most lignocellulosic (non-edible) feedstocks
  ▪ Wood chips, sugar cane bagasse, straw, sunflower husk, etc.

<table>
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<th>Typical Pyrolysis Oil Characteristics</th>
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<td>Composition</td>
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<td>Density</td>
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<td>Heating value</td>
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<td>• Water content</td>
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<tr>
<td>• Ash</td>
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<td>• Acidity (pH)</td>
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1.2: Why pyrolysis?

- Decouple biomass resource from location and scale of application
- Works with a variety of biomass feedstocks
- Yields a homogeneous, 2nd generation liquid, that serves as a sustainable alternative to fossil fuels
- Produces bio-oil which is easier to store and transport due to significant volume reduction of solid biomass of about 12 on average
- High overall efficiency of ~85%: Conversion of biomass to main & by-products
- Versatile application: Heat, power and transportation fuels
- Utilize existing fossil fuel infrastructure:
  - Pyrolysis oil provides a viable link between the agriculture and (petro-) chemical industry.
  - Renewable feedstock for petrochemical industry in the production second generation biofuels
1.3: Fast Pyrolysis Bio-Oil Process

- Intensive mixing of **biomass** particles and **hot sand** in absence of air in the **REACTOR**
- **char** and **sand** are recycled to a **COMBUSTOR** where the char is burned to reheat the sand
- Vapours leaving the reactor are rapidly cooled in the **CONDENSER** yielding the **pyrolysis oil** and some gases.
- The **gases** and the surplus heat from the combustor can be used to generate **steam** for **power** generation, **biomass drying** or **external use**
- The minerals contained in biomass stay behind in the **ashes**. They can be **reused** locally, thus avoiding mineral depletion
2. Technip – BTL Collaboration

- Rolling out fast pyrolysis bio-oil (FPBO) technology & commercial production
2.1: Technip – A World Leader in the Energy Industry

- Global footprint with ~32,500 people in 45 Countries
- Global expertise in Engineering, Procurement and Construction (EPC)
- Technology leader in Hydrogen, Ethylene, Refining & Petrochemical
- Advancing innovative, green solutions to meet the world's energy challenges

Technip’s mission is to deliver safe, sustainable, quality and successful projects
2.2: BTG Bioliqids

- Active in research and development of biomass technology
- Patented fast pyrolysis oil technology
- Reference commercial production plant with operational know-how

BTG Bioliqids contributes towards a sustainable society by providing a renewable alternative to fossil fuels.
2.3: Technip – BTL Collaboration

- Green technology
- Complete turnkey (EPC) delivery of the Fast Pyrolysis Bio-Oil (FPBO) units
- Operational support for commercial production of pyrolysis oil
- The link between biomass (agricultural) and petrochemical Industries

We offer **proven technology** and **EPC expertise** for **modular** pyrolysis oil units.
2.4: Benefits of Technip – BTL FPO Plants

- Plant functions **autonomously** (stand-alone installation)

- **High operating plant efficiency** (~ 85%) as no external fuel or power is consumed during normal operation

- Plant can produce enough LP **steam** to dry biomass from 55%.wt moisture content down to 5%.wt moisture

- At lower biomass moisture content, plant can:
  - Export **excess steam** to an external local user and/or,
  - **Electricity generation** via steam turbine, enough for the plant and export excess to an external grid.

- Absence of inert carrier gas recycle, results in minimum downstream equipment size and thus a small plant with **low CAPEX**.

- **Modular** approach for turnkey delivery of pyrolysis oil plant
  - Shorter delivery time and safer construction

- Plant can be operated and controlled by **one operator**
3. Commercial Production
Empyro Plant in Hengelo, the Netherlands

Plant Data
- **Plant Capacity**: 120 tonnes of dry wood residue/day
- **Plant Feedstock**: Wood Residue

Plant Output per year
- **Oil**: 20 million litres
- **Electricity**: 2,200 MWh
- **Steam**: 80,000 tonnes
- **CO2- eq. reduction**: 24,000 tonnes
Update Empyro after 2 years of operation

- Scale up successful, our modified RCR (Rotating Cone Reactor) performs very well
- Some start-up challenges (‘teething troubles’) as was expected but Empyro uptime gradually increasing
- Process is stable and easy to control (only one operator during the night shift)
- Oil quality has been excellent from the first batch and remained highly constant since
- September 2017: 18 million liters of oil produced at Empyro!
- Running at 3.3 tons of oil per hour (design capacity) at the moment
4. Fast Pyrolysis Bio-Oil Applications

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4.1 Pyrolysis Oil Application
Industrial Steam Generation at FrieslandCampina

Schematic drawing of Process Steam Boiler at FrieslandCampina

Flue gas re-circulation

Process Steam (40 t/hr, 21 bar)

Boiler  1\textsuperscript{st} ECO  Dust Filter  2\textsuperscript{nd} ECO  Stack

FPBO

Natural gas  Air

Flue Gas
4.1 Pyrolysis Oil Application
Industrial Steam Generation at FrieslandCampina

Picture taken of the inside of the FCD boiler when firing both pyrolysis oil and natural gas
4.2: Heat & Power Generation

Gas Turbines can be used to produce electricity and heat in a combined heat and power plant.

- Generation sets can be adapted to run on pyrolysis oil e.g. Opera Turbines.
- Heat and power applications in oil & gas, industrial, commercial and marine sectors.
**4.3: Co-FCC Route**
Based on Technip FCC Technology

**Co-refining** FPBO in FCC enables production of 2nd generation bio-fuels while utilizing existing refining infrastructure.
4.4: Technip FCC Capabilities

- Over 35 years experience in the development, design and construction of its own FCC technology
- The most experience in revamping technology upgrades on FCC licensed by others
- Formed FCC Alliance in 1993 with IFP/Axens and Total
- Several FCC Alliance achievements including
  - 61 grassroots FCCs
  - More than 250 FCC revamps
  - 90 FCC related patents

Offer **cost-effective** solutions to meet refiner’s bio-energy challenges and obligations via application of **FCC Co-feeding route**
4.5: Transition Towards a Bio-based Economy

Technip and BTL are developing the Co-FCC Route to facilitate:

- Bio-based feedstock (FPBO) for the petrochemical industry
- Refining industry production of second generation biofuels and bio-based products while utilizing existing infrastructure
- A viable and cost effective development of a bio-based economy in order to meet renewable energy and sustainability targets
THANK YOU

Technip Benelux B.V.
P.O. Box 86
2700 AB Zoetermeer
The Netherlands
+31 79 3293600
jdejager@technip.com
www.technip.com

BTG BioLiquids B.V.
P.O. Box 835
7500 AV Enschede
The Netherlands
+31 53 486 2287
gerhard.muggen@btg-btl.com
www.btg-btl.com