Advancing pyrolysis oil production: A catalytic leap towards sustainable bio-based fuels and chemicals

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TCBiomass 2024

Valmet

Committed to moving our customers' performance forward

Valmet

Valmet is a leading global provider of biomass conversion technologies

- Personnel 19,160 around the world
- 220 years of industrial history
- Net sales in 2023: 5.5 billion EUR
- Listed on the Nasdaq Helsinki

Industries we serve:
Board and paper, Energy, Pulp, Tissue

Valmet offering:
Technologies, Services, Automation solutions, Flow control

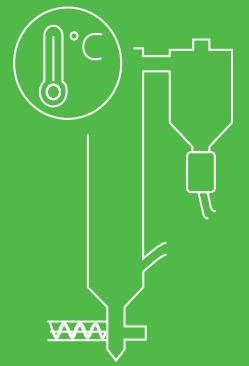
Pulp technologies

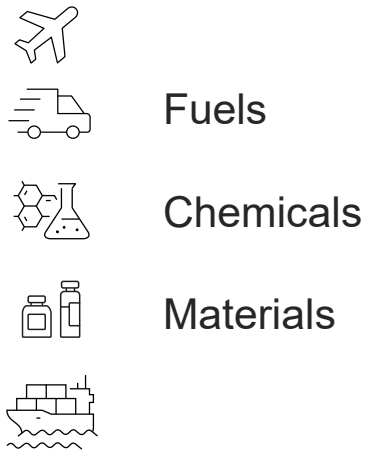
- Pulp and paper technologies
- Valmet BioTrac for biomass pretreatment
- Steam explosion

Energy technologies

- Heat and power generation
- **Pyrolysis**
- Gasification
- Air emission control

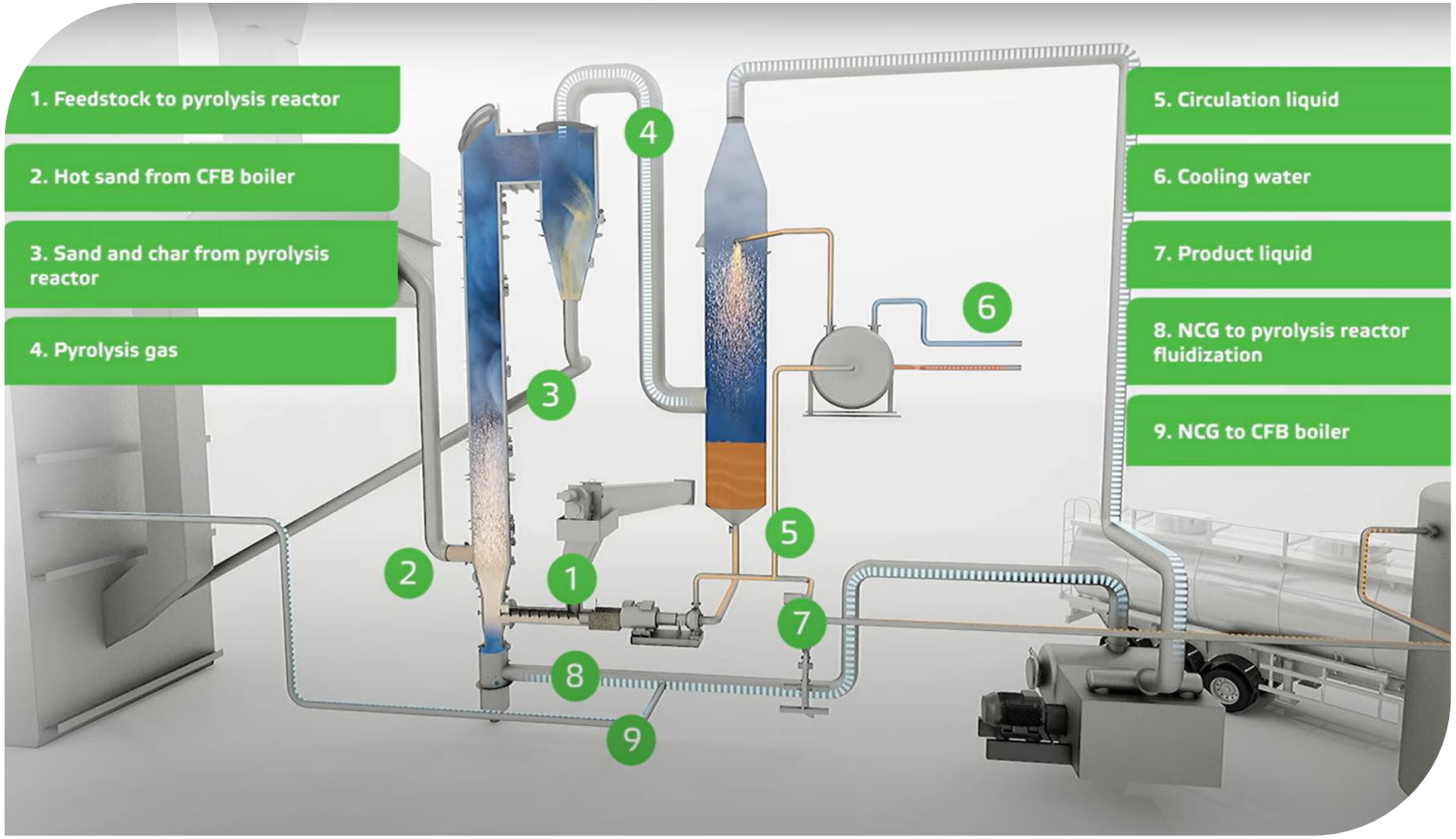
Valmet Pyrolyzer





Large industrial pyrolysis unit, 50 kton/a of FPBO

Pyrolysis oil production to replace heavy fuel oil



Fortum CHP-integration, Joensuu, Finland

Start-up 2013

Video available in Youtube: Link

Industrial scale biochemical production

Valmet Pyrolyzer produces LGO for Cyrene™ production by Circa

- Environmentally friendly multipurpose solvent
- Patented Furacell™ process adapted by Valmet
  - Lignocellulosic biomass input 2 t DS/h
  - Valmet supplies feedstock handling, CFB, pyrolysis and condensation

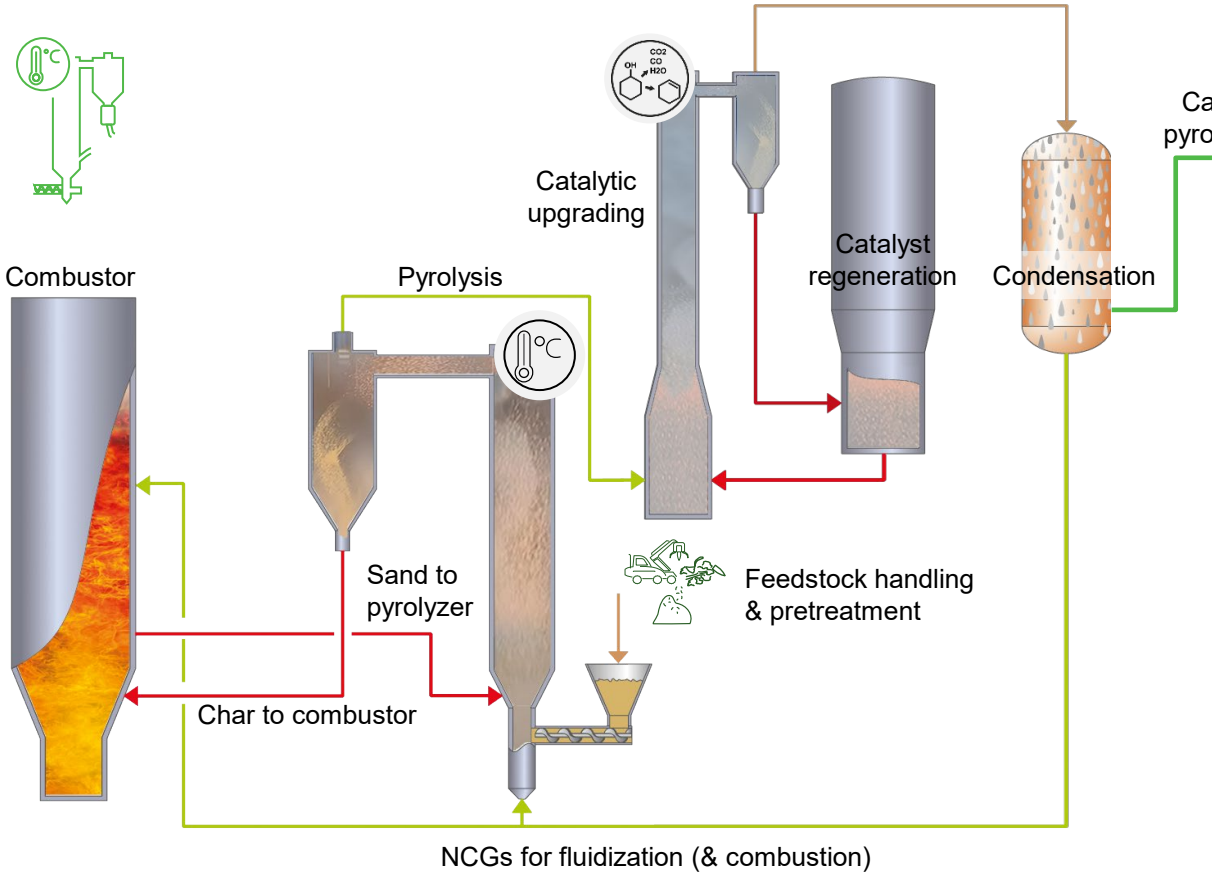
- Efficient integration of pyrolysis and distillation enable sustainable energy production
- Project deliveries ongoing

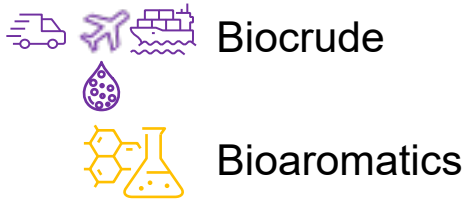
Circa ReSolute, Carling, France

Source: Circa

Valmet

Valmet Pyrolyzer with catalytic upgrading





- Result of 20 years of experience in pyrolysis and 10+ years of catalyst development in collaboration with JM
- Deoxygenation and aromatization of pyrolysis vapors to produce a condensate with low O and low acidity
- Separate stages for pyrolysis and catalytic upgrading
  - Reduction of catalyst contamination from impurities in the feedstock
  - Process parameters can be controlled independently in pyrolysis and catalytic stages
- Commercial concept for 100 kta production unit

Valmet offers the entire plant solution including automation and services

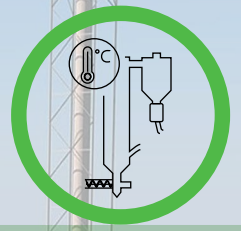
Feedstock

- Lignocellulosic biomass: woodchips, sawdust and forest residues

Pretreatment

- Feedstock receiving
- Drying & sizing
- Conveyors, storage and feed equipment

Pyrolysis



- Thermal pyrolysis
- Catalytic upgrading of pyrolysis vapors
- Condensing, separation and storage of products

Refining

- Hydrothermal processing (HDO) to drop-in products

or

- Co-processing with fossil feeds in refinery (e.g. FCC co-feed)

Products

End-products: compatible hydrocarbons in Diesel, Jet and Gasoline-range

Valmet core technologies

- Valmet can provide the entire plant, including needed boiler systems and automation
- Valmet offers service and maintenance for operation phase

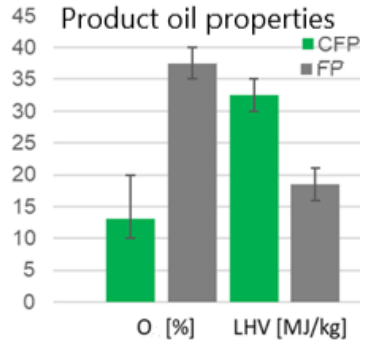
Catalytic pyrolysis pilot plant ready to serve!

Valmet Energy R&D Center in Tampere, Finland

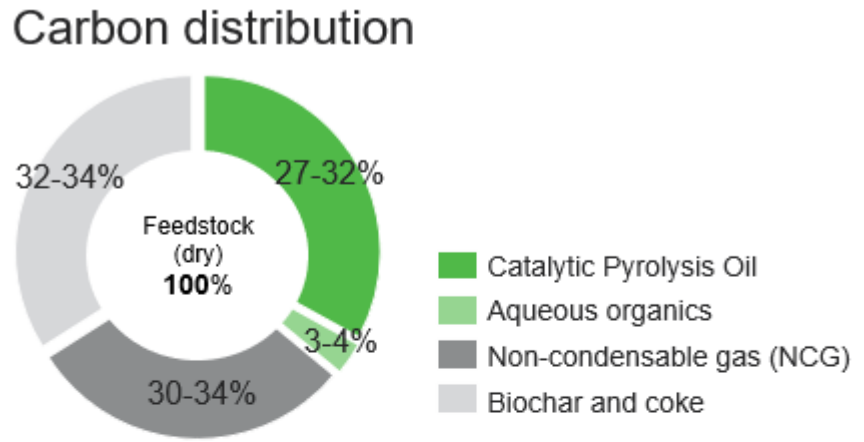
- Fast pyrolysis pilot started up in 2008
- Pyrolysis pilot with continuous catalytic treatment of pyrolysis vapors completed in 2023
  - Design of demo/commercial unit + down-scaling to pilot
  - Feed capacity 10 tons/d, production rate of several tons of liquids/day
  - Various biomass feedstock can be tested
  - Operates at atmospheric pressure, 24h/day
  - Pilot testing performed in campaigns
- Reference plant for process and concept development
- Equipped with Valmet DNAe control system

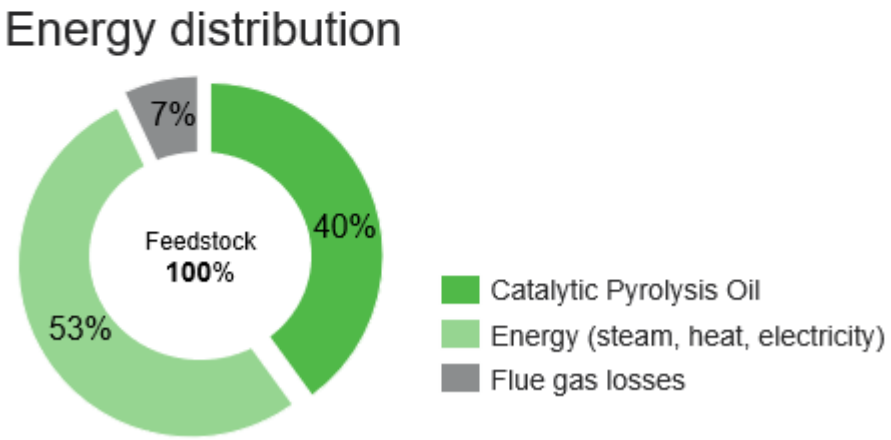
Valmet pilot experiences and product properties

- Product yield & quality in line with previous references
- Feedstocks: dried & milled biomass
- Product liquid properties
  - Oxygen content range: 10-20%
  - Acid number: 10-30
  - High heating value: >35 MJ/kg



- Biomass carbon is distributed in recoverable streams
  - Catalytic pyrolysis oil for upgrading
  - Non-condensable gas and char/coke for energy recovery
  - Plant energy yield ~90%
- Downstream treatment verified with technology suppliers





Valmet pilot experiences and product properties

Liquid product distribution

Bioaromatics (light organics)*		
C	88-90	w-% db
H	8-9	w-% db
N	0,1	w-% db
O	2-4	w-% db

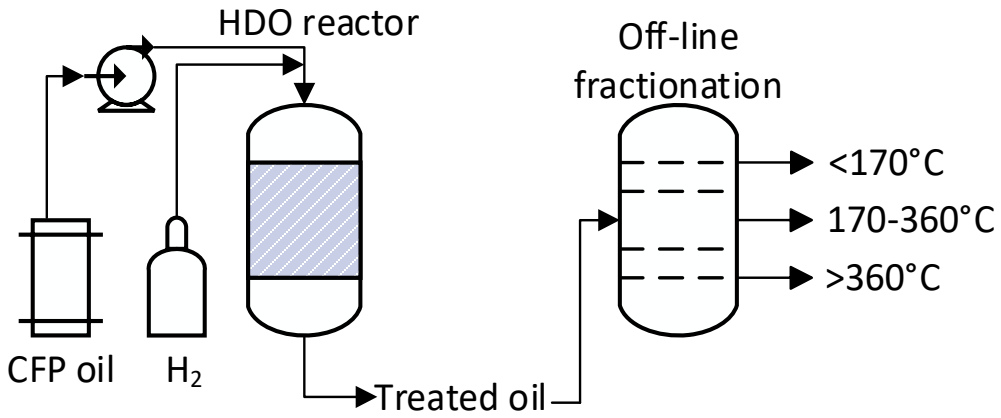
Biocrude (heavy organics)*		
C	78-80	w-% db
H	7-7,5	w-% db
N	0,1	w-% db
O	12-14	w-% db
Water	4-6	w-%
Visc.	13-14	mm2/s (40C)

Bioaromatic composition*		
Benzene	2,6	w-%
Toluene	24,9	w-%
Ethylbenzene	3,4	w-%
Xylene (m,p,o)	32,3	w-%
Total other aromatics	32,2	w-%
Phenols	0,3	w-%
Total BTEX	**63,1**	**w-%**
Total Aromatics	**95,7**	**w-%**

* Composition depending on operational parameters

Hydroprocessing of CFP-oil

Experiments at Topsoe show high yield of fuel range components



Schematic drawing of used setup at Topsoe

Product distribution	Naphtha (<170°C)	Diesel (170-360°C)	Residue (>360°C)
Yield (wt%)	27	64	9
S (wt ppm)	<1	<1	<1
N (wt ppm)	0.2	0.2	1.2
Aromatics (wt%)	14	7.8	4.4
RON (D 6839)	84		
Cloud (°C)		-26	
Pour (°C)		-84	

Source TOPSOE

Valmet is actively developing pyrolysis towards commercial scale

- Catalytic pyrolysis offers an attractive route to biofuels from solid biomass
- We are capable of industrial piloting to produce feedstock for biofuels at tons per day scale
- Next step is to advance the technology into demonstration and commercial scale by collaboration across the value stream
- We are open to joint development in both confidential and public projects


Valmet
FORWARD