Karlsruhe Institute of Technology

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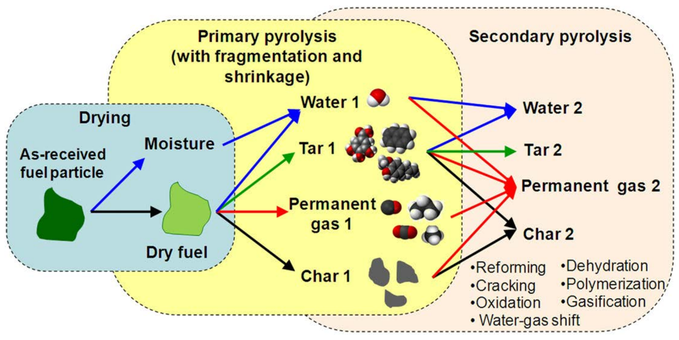
Engineering fast pyrolysis of biomass: Influence of product recovery



Source: Neves et al. (2011); http://dx.doi.org/10.1016/j.pecs.2011.01.001

Thermal degradation of a solid biomass particle under inert atmosphere

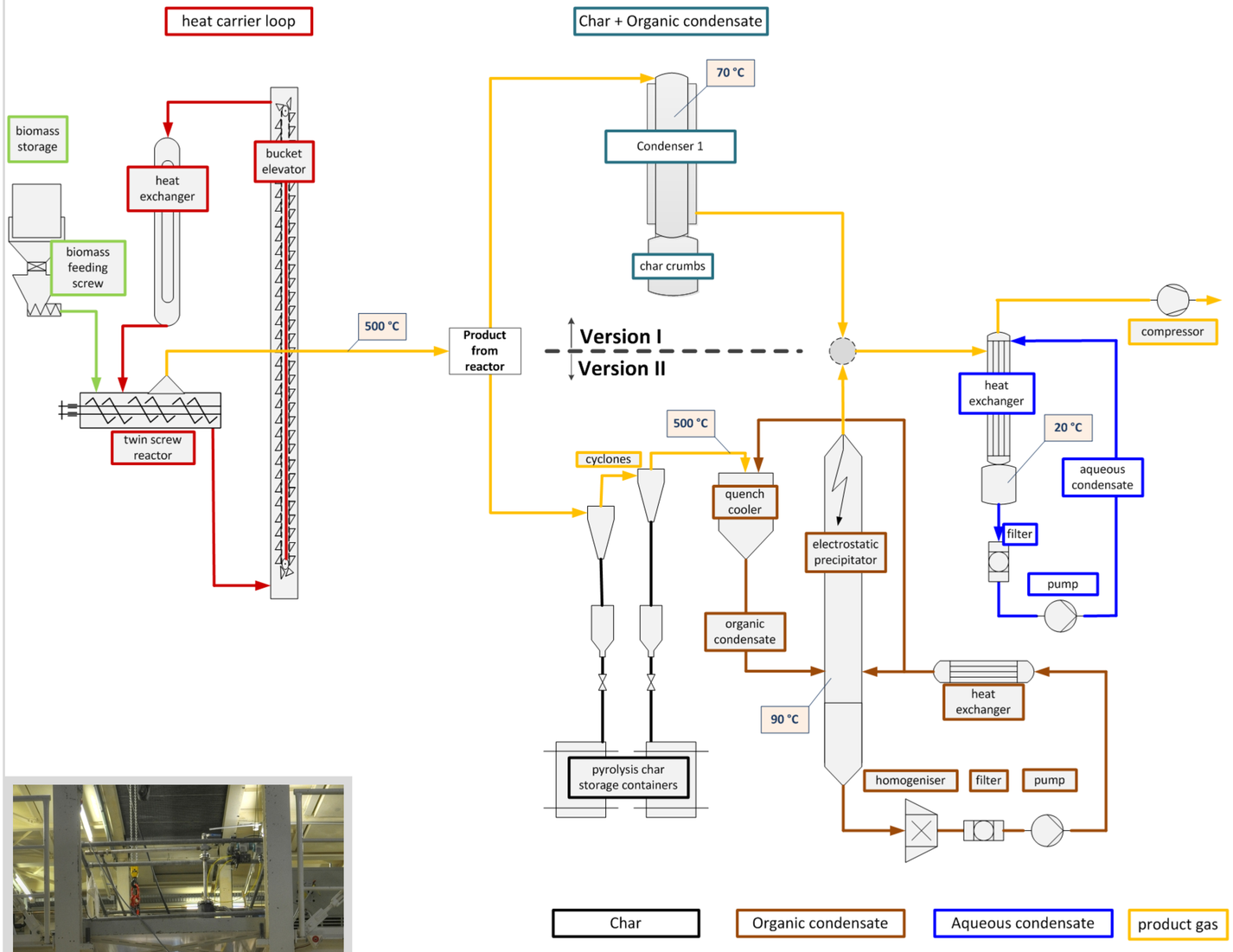
The first stage of the Karlsruhe bioliq® process converts agricultural residues such as e. g. straw to an energetically densified ‚biosyncrude' in decentralized units. This biosyncrude is suitable for transportation to central, large scale gasification units. The produced synthesis gas is used to produce fuels and chemicals.

The biosyncrude is produced by fast pyrolysis. The IKFT is operating a pilot plant with a scale of 500 kg h^{-1} biomass input and a smaller 10 kg h^{-1} unit at KIT. This smaller unit is used for process development, e. g. for testing different product recovery concepts, and to establish mass and energy balances for a variety of different biomass. Both fast pyrolysis units achieve the required heating rates by mixing a preheated heat carrier in a twin-screw mixing reactor.

http://www.bioliq.de/

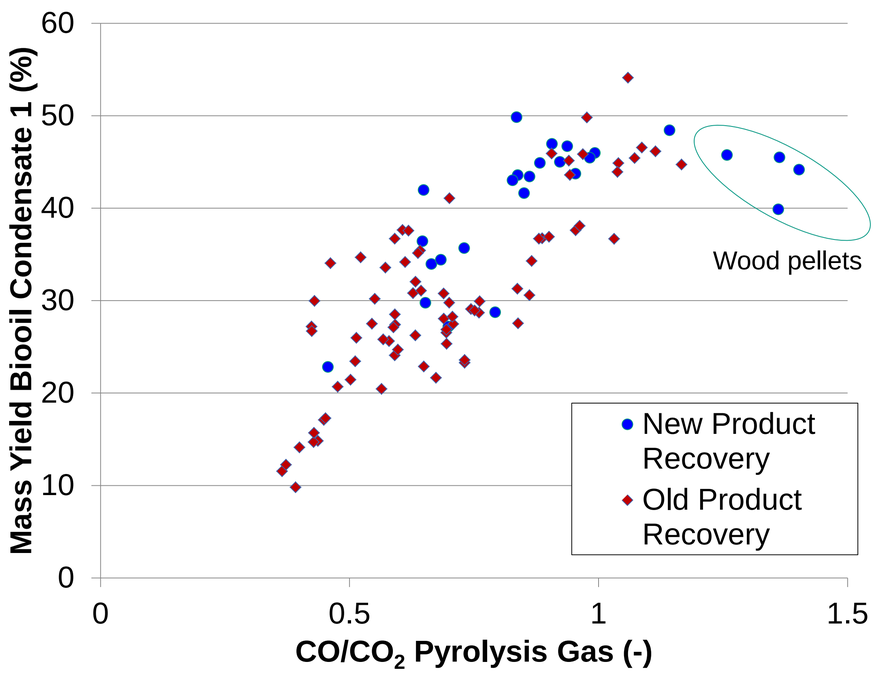
The products need to be cooled down rapidly (<2 s) in order to avoid unwanted secondary reactions.
In a first version, vapors were condensed together with char at 70 °C in an indirect heat exchanger.
This product recovery has been changed to a separate solids removal and subsequent quenching of vapors at 90 °C.
Despite the higher condensation temperature, organic oil yield was improved significantly as compared to the first version.

Flow chart of process demonstration plant “Python” (10 kg/h biomass input) - First and second version



During years of testing and operation, more than 100 experiments with 22 different types of biomass have been conducted and evaluated.

It has been proposed that the CO/CO_2 ratio in the pyrolysis gas can be correlated to the organic oil yield. This can be supported by the wealth of experimental data with one consistent experimental setup.
Within the biomass tested, there is only one set of outliers for the case of wood pellets.



Products recovered with “Python” (Version II)

Char

Yield (wt%,ar)	ca. 25
HHV (MJ/kg)	18 - 26
Ash content (wt%)	20 – 40
Bulk density (kg/m³)	300 – 500

Organic condensate

Yield (wt%,ar)	ca. 35
HHV (MJ/kg)	~ 20
Water content (wt%)	10 - 35
Bulk density (kg/m³)	~ 1200
Solid content (wt%)	<10

Aqueous condensate

Yield (wt%,ar)	ca. 25
HHV (MJ/kg)	~ 5
Water content (wt%)	70 - 85
Bulk density (kg/m³)	~ 1000
pH	~ 3

Product gas

Yield (wt%,ar)	ca. 15
HHV (MJ/kg)	ca. 9

to be used internally

*Average values for wheat straw

Conclusion: Product recovery is significant for the product distribution and quality. It proved to be decisive for the operative condition of fast pyrolysis.