Aerosol formation during the condensation of fast pyrolysis vapours

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During fast pyrolysis, lignocellulosic biomass is thermally decomposed in the absence of oxygen at about 500°C. The resulting pyrolysis vapours are then condensed and form pyrolysis oils. The condensation can be realised in a single or in a multistep condenser with direct or indirect cooling. In almost every constellation aerosols are formed, which have a significant influence on the heat and mass transfer and the optimum design of the product recovery. The aim of this work is the simulation of the condensation process in a fast pyrolysis unit with aerosol formation. Therefore the product recovery of the fast pyrolysis unit of the bioliq® process (Dahmen *et al*, 2012) is modelled.

The product recovery in this process is shown in figure 1. The vapours enter the condensation system with about 500°C. In a first step the char is separated in a hot gas cyclone. Then the vapours are condensed in a spray column down to about 80°C. As quenching liquid, the condensate itself is used. The formed aerosols are separated in an electrostatic precipitator. In a second condensation stage, the gas is quenched again by its own condensate to room temperature, where also aerosol formation can be observed.

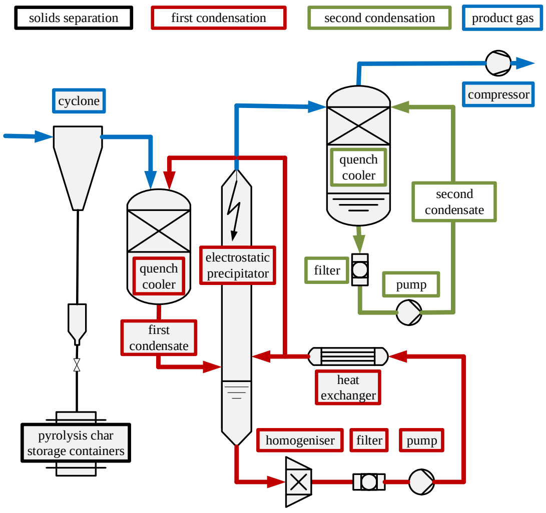

Figure 1. Product recovery in the bioliq® process.

The process is modelled with the simulation tool AerCoDe (Ehrig *et al*, 2002) which has been developed to calculate exhaust gas cleaning processes. The tool was extended to multi component systems and 30 different components relevant to biomass degradation have been implemented which can be separated in three different groups as shown in table 1. The pyrolytic lignin, as a non-volatile component, is often not considered in the literature due to the questions of how they are transported into the pyrolysis oils. Experiments show that these components at least partly are thermally ejected from the pyrolysis reactor as aerosols (Daugaard, 2003). To describe the process with a correct mass balance, the considering of aerosols is therefore essential.

Table 1. Typical composition of fast pyrolysis vapors at the product recovery inlet.

Type	Components	wt%
Inert gases	N_2, CO_2, CO	34 wt%
Volatiles	Water, organic acids, ketones, furans, phenols	34 wt%
Non-volatiles	Pyrolytic lignin	32 wt%

In figure 2, first results for the modelling of the second stage of the condensation process with and without aerosol formation are displayed. The simulations show a big influence of the aerosol formation on the heat and mass transfer.

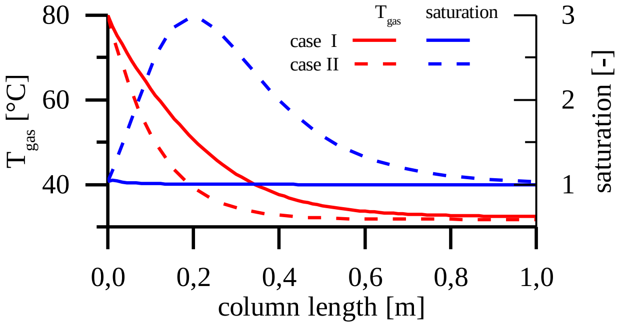

Figure 2. Gas temperature and saturation during condensation with (I) and without (II) aerosol formation.

Especially the temperature characteristics along the quench vary due to aerosol formation. As dwell times at different temperatures have a great influence on the chemical reactions and therefore the quality of the pyrolysis oils, understanding those processes is highly important for an exact design of the quenching unit and a stable process operation and control.

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