BIOMASS GASIFICATION IN PRESENCE OF CO2, H2O OR O2 AT HIGH TEMPERATURE IN ENTRAINED FLOW REACTOR: EXPERIMENT AND MODELLING

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The present study aims at better understanding biomass gasification phenomena in EFR which is one of the most promising technologies for BtL process. We applied a double approach using experiments in a Drop Tube Reactor (DTR) and modelling with a 1D model using detailed chemical scheme.

Influence of different oxidants was studied: O_2 (λ=0.24-0.44-0.61), steam (H_2O/biomass=0.55 g/g of dry biomass (db)) and CO_2 (CO_2/biomass=0.87 g/g db). The biomass was beech wood particles (300-450 µm). Experiments were conducted between 800 and 1400°C with a constant gas residence of 4.3 s. Gaseous products were analyzed online by a gas chromatograph and a psychrometer. Char and soot were collected and characterized. Tars were trapped using tar protocol and analyzed by GC-FID.

Most interesting experimental results are that adding of steam or CO_2 has no influence on char conversion at temperature below 1200 °C. Tars were detected only at 800 and 1000 °C and the major species were benzene, naphthalene, phenol, indene, toluene and styrene. We can notice that at 1400 °C at λ=0.44 the char yield is hardly completely consumed (η_{char} = 0.5 w% db).

These experiments were successfully simulated with a previously developed 1D modelling tool named GASPAR [1]. The model includes thermal and chemical phenomena description: heating of carrier gas and wood particles; biomass drying; chemical reactions: pyrolysis, gas phase reactions using detailed chemical scheme, soot formation and char gasification. The differential equations related to gas, tar and soot production and reaction in the gas phase are calculated with CHEMKIN II. Then the differential system is solved with LSODE solver which is appropriate for stiff system.

The major hypotheses of GASPAR are:

- The drop tube reactor is modelled as a plug flow reactor.
- The particles are supposed to be spherical; temperature and concentrations are supposed to be uniform inside the particles.

The slip velocity between particles and gas is taken into account as the modifications of the particle characteristics during the pyrolysis reaction, namely the particle bulk density and the particle equivalent spherical diameter.

In order to improve the prediction capability of the model, the gas phase reactions were modelled using a detailed kinetic scheme. The Ranzi and co-workers kinetic scheme (176 species, 5988 reactions) [2] was selected for gas phase modelling. It is a detailed/lumped mechanism of the pyrolysis, partial oxidation and combustion of Primary Reference Fuels. It takes into account all the tars used here in the global pyrolysis reaction. It was validated in relevant experimental conditions and it predicts PAH formation up to C20 which is convenient for the soot formation modelling [3].

The modeling tool was improved, especially concerning the pyrolysis reaction, the gas phase reactions and the gasification reactions.

Thanks to this double approach using experimental results and modelling, a comprehensive gasification model was validated. It allowed a very satisfying prediction of gas, tar and char yields.

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