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Experimental investigations and modeling of devolatilization based on superimposed kinetics of biomass

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Abstract

A non-isothermal one-dimensional model has been developed to describe biomass pyrolysis at fast heating rate ($600\text{-}10^4\text{ K s}^{-1}$), high temperatures (up to 1500°C) and is valid for different biomass particle sizes ($< 10\text{ mm}$). The model was developed to estimate the yields of volatile gas and char. The model relies on the concept applied in fast pyrolysis of cellulose through the formation of an intermediate liquid (so called metaplast) which reacts further to char and gas. The kinetics of the fast pyrolysis was described by the Broido-Shafizadeh scheme.

The influence of particle size and shape was included in the model. Cylindrical representation of a biomass particle shape was chosen to be the most suitable in the pyrolysis model. The evolution of devolatilization time required for the complete pyrolysis showed that the particles with a mean diameter $< 0.45\text{ mm}$ may be considered as thermally thin at high heating rates. The predicted results by one-dimensional model are in agreement with the experimental work, and emphasize a key role of intra-particle heat conduction in biomass particles $> 0.45\text{ mm}$.

The potassium influence on the char yield was implemented in the model based on the experimental results in the wire mesh and drop tube reactors with respect to the stronger catalytic effect of potassium on the char yield at low and intermediate heating rates compared to pyrolysis at high heating rates. The heating rate and potassium content affected significantly the char yield as evidenced from the experimental data obtained in the wire mesh and drop tube reactors. Thus, the model including these two parameters provides an acceptable fit of char yield to the experimental data. The present results showed that the proposed kinetic model for the fast biomass pyrolysis is relatively simple and predicts reasonably accurately the char yield of woody and herbaceous biomass particles $< 10\text{ mm}$ using one fixed set of kinetic parameters valid for woody and herbaceous biomass.