

A COMPREHENSIVE NUMERICAL TOOL FOR THE ADVANCED MODELLING OF PYROLYSIS, COMBUSTION AND GASIFICATION OF BIOMASS

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The present work focuses on the comprehensive modelling of biomass decomposition, taking into account both pyrolysis and char gasification reactions. The motivation of the work resides in the fact that biomass materials represent a domain of growing interest and development in the current energy scenario. In this context it is utmost of important spend modelling efforts in the direction of a clearer and deeper understanding of biomass characterization, in order to develop and address the technological implementation of processes for the effective exploitation of biomass potential.

A numerical model of biomass decomposition has been developed at the particle scale in order to describe the relative role of reaction kinetics and transport phenomena. The model solves mass and energy balance equations for gas and solid species employing a finite volume method (FVM) discretization of 1D-spherical domain.

The kinetic model involves both the multi-step devolatilization and decomposition of three key-biomass reference species (cellulose, hemicellulose and lignin) and the char gasification and combustion with steam, air or oxygen.

The aim of this work is to study the impact of shrinking and non-shrinking biomass particle on the definition of physically parameter such as particle porosity and radius. Different experimental studies have shown that both particle diameter and apparent density vary during biomass decomposition consistently with the operating conditions. The model is able to provide this physical trend exploiting the different mass conversion rates in each discretized domain.

In particular, at high temperatures the mass loss rates is limited by the rates of reactant diffusion to the outer surface of the particle, hence it reacts primarily at its periphery. The apparent density (or porosity) is relatively unchanged, while its diameter varies with the mass loss in a shrinking-based model. Conversely, at low temperatures the mass loss rates is limited by the chemical reaction rates and the particle reacts more or less uniformly throughout its volume. The particle size is relatively unchanged and the apparent density varies proportionally with mass loss. At intermediate conditions particles decrease in both size and apparent density and the mass conversion rates are limited by the combined effects of chemical reaction and pore diffusion.

In order to validate the reliability of the model, the results of the simulations have been compared with the experimental thermogravimetric (TG) curves and porosity data provided in literature in a wide range of operating conditions.

10.4405/profic2014.B14