Modeling thermochemical conversion of solid biomass in a straw fired furnace

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Renewable energy generation is promoted by rising awareness about climate change and fluctuating prices of fossil fuels. Therefore, technology based on thermochemical conversion of biomass is increasingly applied for heating and combined heat and power (CHP). However, it is a major challenge to design biomass furnaces with low pollutant emissions and high efficiency. A common approach for design improvement is to analyze the geometry and operating parameters with CFD (Computational Fluid Dynamics), as numerical simulations are an ideal supplement to experimental investigation.

In the framework of an international research project, a straw fired furnace is investigated. This furnace is used for the batch wise incineration of whole bales of straw. Its power output of approximately 1 MW, is mainly applied for heating. Additionally, electricity is produced using an Organic Rankine Cycle (ORC).

Modeling of biomass combustion involves thermochemical conversion of the solid fuel and gas-phase reactions in the freeboard. The two processes are strongly coupled by heat and mass transfer. The focus of this study is on the modelling of the combustion of straw inside the fuel bed. An existing OpenFOAM solver, namely biomassGasificationFoam [1], is enhanced for straw combustion.

Biomass undergoes different phases, drying, pyrolysis, gasification and combustion, during its thermochemical conversion in an oxidizing environment. All these phases are modeled in the presented solver. Conversion of biomass is described using a porous medium approach. The transport equations of both phases (solid and gas) are solved using source terms. New kinetic parameters for pyrolysis, determined by experiments and reactions for biomass combustion, were added to enhance the solver. Simulation results using the bed model with the new features showed good agreement with measured data. The next step is to develop the solver further and to adapt it to different applications as well as various biomasses.

References:

[1] KWIATKOWSKI, K ; ZUK, P J ; DUDYŃSKI, M ; BAJER, K: Pyrolysis and gasification of single biomass particle – new openFoam solver. In: *Journal of Physics: Conference Series* Bd. 530 (2014), S. 12-15