DEPARTMENT OF ENERGY TECHNOLOGY
AALBORG UNIVERSITY

PhD Public Defence

Title: CFD Modeling of Biomass Thermo-Chemical Conversion and Its Experimental Study

Location: Online (find stream link on et.aau.dk) - PON 101 1.001

Time: Monday 14 September 2020 at 13.00

PhD defendant: Xiyan Li

Supervisor: Professor Søren Knudsen Kær

Co-Supervisor: Associate Professor Thomas Condra

Moderator: Associate Professor Henrik Sørensen

Opponents: Associate Professor Matthias Mandø, Dept. of Energy Technology, Aalborg University (Chairman)
Professor Henrik Kofoed Nielsen, University of Agder
Professor Britt M.E. Moldestad, University of South-Eastern Norway

All are welcome. The defence will be streamed live in English.

DEPARTMENT OF ENERGY TECHNOLOGY
AALBORG UNIVERSITY

Abstract:

Understanding what is going on during biomass thermochemical conversion process is one of the technological hurdles in biomass thermal treatment. In this project, a reliable one-dimensional biomass pyrolysis/gasification/combustion model has been developed and programmed. The model developed is integrated into a finite volume based CFD code. A sequence of partial differential equations are discretized by central difference approximation spatially and an implicit method temporally, the discretized equations are solved by the tridiagonal matrix algorithm (TDMA). The model can reliably predict the temperature distribution, the pressure distribution, the species concentration, the size changes, spatially and temporally.

The project is divide into two parts. The first part is the development of a reliable one-dimensional single biomass pellet pyrolysis model. The model is verified using various experimental test cases. After that, the model is extended to a combustion model, by including more oxidation reactions. For both pyrolysis and combustion case, the experimental data for mass loss and temperature profile of a biomass particle under different conversion condition are collected from the literature for model validation. The second part of this project is designed to further investigate the combustion mechanism in more realistic operating conditions and in this part an experiment is done on a packed-bed biomass combustor in the laboratory of BEST - Bioenergy and Sustainable Technologies GmbH at Graz university of technology. A series of tests were performed to investigate the effect of the primary air flux on the in-bed biomass combustion behaviour under normal air-firing condition (79% N2 and 21% O2 (vol)). Measurements include the mass loss of the bed, the temperatures in different bed locations, and the release of gas species O2, CO, CO2, NH3, HCN, NOx, SO2, hydrocarbons by means of FTIR and FID.
The experiment not only provided a physical understanding of the underlying conversion process and mechanisms under different operating conditions but also provided more detailed data for validating the model developed in the first part. For the smouldering combustion under 30 l min-1, a comparison is made between the experimental results and the model simulation.