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Paweł Kazimierski PhD dissertation Abstract:

"Research and analysis of biomass gasification in a moving bed reactor using radiographic methods"

The work compromises the subject of fuel conversion with advanced analytical methods for in-depth recognition of chemical, physical and mechanical phenomena occurring during biomass thermal processing. A strong emphasis is put on the pyrolysis and gasification process, particularly the dynamics of bed movement. Novel techniques were implemented allowing for a comprehensive and thorough investigation of the thermal decomposition process progress. The main method used for the bed movement evaluation was X-ray radiography. Four research theses were formulated. These concern the possibility of using radiographic techniques for thermochemical biomass conversion studies, in particular for single biomass particle tracking as well as fuel bed setting rate. One of the thesis was also an assumption that the bed motion during the process inside the gasifying reactor is not uniform. The experiments were carried out with the use of two gasifiers: co-current (downdraft) and counter-current (updraft), three pyrolysis reactors and dedicated high-temperature furnaces. For the radiographic methods three sources of radiation were used: Se-75 isotope, an industrial X-ray tube and low-power X-ray tube.

The work presents the results showing the unstable dynamics of biomass bed in the gasifying reactors. The study provides knowledge on the nature of the gasification process. For downdraft gasifier the fuel tunneling was observed in the zone over air nozzles, which indicates intense decomposition processes. Downdraft gasification was characterized by a rapid bed settling above air nozzles and sudden change in bed dynamics after passing the nozzle area. For updraft gasifiers the bed motion was in general much more uniform and less dynamic. This corresponds to the process being more stable in the case of updraft gasification. In addition to purely scientific value of this work, the results are also easily implemented for industrial purposes. The pyrolysis research included the balance of the obtained fractions. Study of surface reactions using carbon dioxide, which was conducted for the simulation of the biomass oxidation in the high-temperature zones, can be used as a study of possible biochar application for activated carbon production.

The main conclusion, considering the possible application of the presented studies for industrial purposes, is that for a more efficient process and better dynamics, the thermal decomposition needs to be split into two separate processes (the gasification process and the complete burnout) conducted in separated thermal devices.