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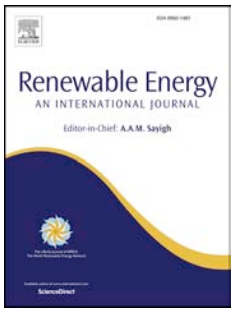

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Numerical Modeling of Homogeneous Gas and Heterogeneous Char Combustion for a Wood-Fired Hydronic Heater

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Abstract

The pyrolysis of woody fuels produces two main products - pyrolysis gases and solid residue char which undergo homogeneous and heterogeneous reactions, respectively. Recent experimental measurements using a two-stage hydronic heater indicate the oxidization of these two products occur at distinctly different time scales with the pyrolysis gases burning immediately, and the majority of the char oxidization occurring later. In this study, these two oxidation pathways are explicitly accounted for in a numerical model that considers a non-homogeneous mixture of product flue gases. The model is based on a three-zone description of the heater which accounts for combustion and heat transfer using well-stirred reactor theory. The first zone describes the gasification of the wood fuel and burning of both pyrolysis gases and char. The second zone represents an after-burning stage. The last stage accounts for the transport of gases out the flue. Model predictions of O_2, CO_2, CO, H_2O and temperature are compared to experimental measurements showing good overall agreement. Furthermore, the dual oxidation pathway description of combustion is shown to be critical to account for the dual-peak CO time signature. The first peak is associated with the burning of pyrolysis gases and the second corresponds to char oxidation.

Keywords: Biomass Combustion, Hydronic Heater, Variable Fuel, Emissions

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