

Experiment and Kinetics Analysis of Char Burnout in a Laboratory-Scale Entrained Flow Reactor (EFR)

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Abstract

The objective is to study particularly the residual carbon-in-ash following the combustion of coal. This poster describes experiments in a tubular, downward-fired, refractory-lined, laminar entrained flow reactor (EFR) that provides the coal with up to a two-second residence time under conditions of pilot scale boilers. Two types of coals are used in order to reaffirm the analysis between a simple kinetics-diffusion (KD) model from FLUENT and a detailed oxidation char burnout kinetics (CBK) model. A thermo-gravimetric analyzer (TGA) is also used to provide comparative oxidation understanding. The three-dimensional KD model incorporated convective and radiative heat transfer at the boundaries, along with heterogeneous and homogeneous combustion chemistry, to evaluate char burnout kinetics validated with the experiments. The simulation did not include detailed devolatilization modeling. The results show that the KD model can successfully achieve essentially equivalent carbon in ash predictions, based on loss on ignition (LOI), at the late stages of char burnout as does the more sophisticated CBK model.

To accomplish the goal of evaluating simulation approaches for accurate prediction of residual carbon-in-ash, we use an entrained flow reactor (EFR) designed to subject char particles to a time, temperature, and oxidizer environment that is representative of a realistic full-scale boiler. The cylindrically symmetric EFR is also duplicated in a simulation geometry. The configuration is similar to that in prior work, but with slightly longer residence time and with considerably more focus on the later stages of char burnout.

Laboratory scale reactors, such as drop tube furnaces (DTF) and entrained flow reactors (EFR), are widely accepted as coal characterization environments that can closely approach the high heating rate and high temperature experienced by coal particles in a utility boiler. In an EFR, devolatilization occurs under much more realistic conditions than is produced by standard ASTM, hot film, wire mesh, or other methods. These reactors can help provide kinetic rates and other useful information regarding the combustion behavior of different coals. In addition, previous studies reported the same trend for LOI in laboratory scale and full-scale experiments. The approach taken in this work provides a realistic thermal coal treatment and measurement of reactivity suitable for comparison with simulations.

