Fly Ash Formation during Suspension-Firing of Biomass. Effects of Residence Time and Fuel-Type

The objective of this work was to generate comprehensive data on the formation of residual fly ash during the initial stages of suspension-firing of biomass. Combustion experiments were carried out with pulverized biomass fuels (two straw fuels and two wood fuels), in an entrained flow reactor at 1200-1400 °C, simulating full-scale suspension-firing of biomass. By the use of a movable, cooled and quenched gas/particle sampling probe, samples were collected at different positions along the vertical axis in the reactor, corresponding to gas residence times ranging from 0.25 – 2.0s. The collected particles were subjected to various analyses, including char burnout level, particle size distribution, elemental composition, and particle morphology and composition. Furthermore, the transient release, i.e. the vaporization of the flame-volatile inorganic elements K, Cl and S, from the burning fuel particles to the gas phase, has been quantified by using two different calculation methods. The ash formation mechanisms were found to be quite similar for straw and wood. The degree of conversion (char burn-out level) was generally good at residence times ≥ 1s. The size distribution of the residual fly ash particles evolved with residence time. For all ashes at long residence times a peak of residual ash particles in the range of 20 – 100 µm was observed. The residual ash particles were rich in Si, K and Ca. Further, at long residence times, submicron particles consisting primarily of KCl (condensed aerosols) became abundant in the ashes from straw combustion. Release of K to the gas phase was nearly 100 % for the two wood fuels and one of the straw fuels. A straw sample (Straw 2) with high Si/K molar ratio and a relative shortage of Ca showed a limited release of K in the range of 65 %; this suggests larger retention of K in Si-rich, Ca-lean fuels, due to incorporation of K into silicate structures. All S and Cl were nearly completely released to the gas phase for all studied samples.

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