

Modeling of sulfation of potassium chloride by ferric sulfate addition during grate-firing of biomass - DTU Orbit (09/11/2017)

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Potassium chloride, KCl, formed from critical ash-forming elements released during combustion may lead to severe ash deposition and corrosion problems in biomass-fired boilers. Ferric sulfate, $\text{Fe}_2(\text{SO}_4)_3$ is an effective additive, which produces sulfur oxides (SO_2 and SO_3) to convert KCl to the less harmful K_2SO_4 . In the present study the decomposition of ferric sulfate is studied in a fast-heating rate thermogravimetric analyzer (TGA), and a kinetic model is proposed to describe the decomposition process. The yields of SO_2 and SO_3 from ferric sulfate decomposition are investigated in a laboratory-scale tube reactor. It is revealed that approximately 40% of the sulfur is released as SO_3 , the remaining fraction being released as SO_2 . The proposed decomposition model of ferric sulfate is combined with a detailed gas phase kinetic model of KCl sulfation, and a simplified model of K_2SO_4 condensation in order to simulate the sulfation of KCl by ferric sulfate addition during grate-firing of biomass. The simulation results show good agreements with the experimental data obtained in a

pilot-scale biomass grate-firing reactor, where different amounts of ferric sulfate was injected on the grate or into the freeboard. In addition, the simulations of elemental sulfur addition on the grate fit well with the experimental data. The results suggest that the SO_3 released from ferric sulfate decomposition is the main contributor to KCl sulfation, and that the effectiveness of the ferric sulfate addition is sensitive to actual temperature in the system. When the ferric sulfate is injected on the grate, the majority of the released SO_3 is rapidly converted to SO_2 due to the high temperatures, resulting in a low effectiveness similar to that of elementary sulfur addition on the grate. On the other hand, when the ferric sulfate is injected into the freeboard where the temperatures are below 1050°C, the majority of the released SO_3 contributes to the formation of K_2SO_4 , leading to a high effectiveness in KCl destruction. Overall, the model developed in this work facilitates an optimal use of ferric sulfate in biomass combustion.

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