Release and Transformation of Inorganic Elements in Combustion of a High-Phosphorus Fuel - DTU Orbit (22/12/2018)

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The release and transformation of inorganic elements during grate-firing of bran was studied via experiments in a laboratory-scale reactor, analysis of fly ash from a grate-fired plant, and equilibrium modeling. It was found that K, P, S, and to a lesser extent Cl and Na were released to the gas phase during bran combustion. Laboratory-scale experiments showed that S was almost fully vaporized during pyrolysis below 700 °C. Sixty to seventy percent of the K and P in bran was released during combustion, in the temperature range 900–1100 °C. The release of K and P was presumably attributed to the vaporization of KPO3 generated from thermal decomposition of inositol phosphates, which were considered to be a major source of P and K in bran. The influence of additives such as CaCO3, Ca(OH)2, and kaolinite on the release was also investigated. Ca-based additives generally increased the molar ratio of the released K/P, whereas kaolinite showed an opposite effect. Thermodynamic modeling indicated that the fly ash chemistry was sensitive to the molar ratio of the released K/P. When the molar ratio of the released K/P was below 1, KPO3 and P4O10(g) were the main stable K and P species at temperatures higher than 500 °C. Below 500 °C, the KPO3 and P4O10 (g) may be converted to H3PO4(l), which may cause severe deposit build-up in the economizers of a grate-fired boiler. By increasing the molar ratio of the released K/P to above 2, the equilibrium distribution of the K and P species was significantly changed and the formation of H3PO4(l) was not predicted by thermodynamic modeling.

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