The impact of multifunctional additives on NO_X emission and bed agglomeration in fluidized bed combustion of biomass

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ABSTRACT

NO_X emission and bed agglomeration are two major concerns in fluidized bed combustion of biomass. While the NO_X emission is determined by a series of competing formation and reduction reactions, bed agglomeration is mainly determined by the release and transformation of inorganic elements, especially potassium, during combustion. A variety of additives exists with the separate purpose of minimizing NO_X emission or bed agglomeration. However, these additives are often multifunctional thereby affecting several ongoing processes. Therefore, the purpose of this study was to investigate the impact of a multifunctional additives on the NO_X emission and bed agglomeration behavior during biomass combustion.

Straw and sunflower husk combustion experiments were performed in a fluidized bed reactor with and without the use of additives. The additives included compounds such as kaolin, lime, ammonium sulphate, coal fly ash, clay, magnesium carbonate etc. Different air staging conditions and additive addition methods (mixing with fuel and batch addition to the bed) were additionally investigated. The NO_X emission was measured using a series of online gas analyzers, while defluidization was observed from the bed pressure drop and temperature. The bed samples were further examined using SEM-EDS and XRD in order to obtain better insight into the agglomeration mechanism.

The results indicate that the conversion of fuel-N to NO increased slightly when pre-mixing the fuels with lime and magnesium carbonate, while a decrease was observed when adding ammonium sulphate due to the facilitation of thermal deNO_X reactions. In contrast to this, kaolin, coal fly ash, and clay had little effect on the NO_X emission from straw combustion, while it increased NO_X emission from sunflower husk combustion. In terms of agglomeration behavior, the results show that kaolin, lime, and magnesium carbonate prevented defluidzation during straw combustion, while ammonium sulphate, coal fly ash, and clay prolonged the defluidization time to some degree. This was explained by the role of additives either in capturing the gaseous potassium species from combustion (kaolin) or reducing the stickiness of formed melts (lime and magnesium carbonate) and thereby the defluidization tendency. Additionally, a comparison between the two addition methods indicates that pre-mixing the additive with the fuel is more efficient in terms of NO_X and agglomeration tendency reduction, most likely due to the better mixing between the fuel and additive.