Abstract

The major motivation for the present thesis is the global warming caused by carbon dioxide emissions. Fossil fuel combustion causes an increasing carbon dioxide concentration in the atmosphere and to cut these emissions, biofuels can replace fossil fuels. Biofuels are in many respects different from fossil fuels and new in large-scale energy production. Reactor design and reconstruction, to be suitable for biofuels, require computer models. These models comprise sub-models of single biomass particles undergoing devolatilisation or pyrolysis. In this thesis the pyrolysis of single wood particles is investigated to provide experimental data suitable for a single particle pyrolysis model. A wood particle is subject to rapid heating by injection into a preheated inert atmosphere. The devolatilisation is studied with methods including thermogravimetry, mass spectrometry and optical methods. Experimental parameters such as temperature and particle size are varied. The mass loss characteristics and kinetics, and the formation of some important gases are described. The shrinkage behaviour of wood during devolatilisation is studied and applied in a wood particle pyrolysis model.

The content of alkali in biofuels is generally high. Alkali causes a number of unwanted effects upon combustion. Studies of alkali release from wood and straw are performed with a technique based on surface ionisation. The alkali emission from wood particles is studied during rapid heating. Actions to lower the alkali emission from straw fuels are studied in a small reactor where the fuel samples are subject to a constant heating rate. The effect of washing the fuels prior to pyrolysis was shown to be strong. The effect of replacing chlorine with sulphate in the fertiliser, supplied to wheat and oat, was shown to have a significant effect on the alkali release from the straw upon pyrolysis.

The alkali level in combustion facilities is often required to be kept below a certain level not to cause problems. In some applications on-line alkali monitoring is required. An alkali probe was developed for on-line use and was applied in pressurised and atmospheric systems during combustion of coal, biomass, demolition waste and oil. The alkali probe was calibrated and its performance was directly compared with two other on-line methods. It proved to measure concentrations consistent with the other methods and also to be reliable and robust.

Keywords: biofuel, pyrolysis, wood, straw, coal, birch, shrinkage, pyrolysis model, alkali, potassium, fertiliser, on-line alkali measurement, surface ionisation

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