Characterizing physical properties of aerosol particles in a bubbling fluidized bed boiler

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Introduction

The utilization of biomass and waste in energy production has increased significantly in recent years. Unfortunately, burning of biomass and waste incineration lead to various ash related problems in power plants. The most well-known problem is the high temperature corrosion of superheaters in a boiler induced by alkali chloride deposition (Nielsen et al., 2000). Altogether, the increased utilisation of biomass fuels and different waste fuels has led to an increased need to study the combustion process and to develop fuel additives against corrosion.

In this study, aerosol measured from a bubbling fluidized bed (BFB) boiler is characterized. The work is based on a previously developed sampling system and the chemical characterization of flue gas particles (e.g. Vainikka et al., 2011). The main purpose of this study is to broaden the analysis of aerosol particles measured with this sampling system and to monitor the effect of ferric sulphate as fuel additive on the aerosol. So far, the chemical composition of flue gas particles has been studied in many different cases, but the physical properties have not been characterized at all. In this study, aerosol size distributions and the physical structure of particles, including particle density and morphology, are considered.

Experimental

The experiments were carried out at a co-incineration plant. During the experiments, four different fuel mixtures, including different amounts of SRF (solid recovered fuel), bark, sludge and peat, were used. The sample was taken either from the superheater or from the 2nd pass of the boiler. The sampling system consists of an air-cooled sampling probe, two ejector diluters and two cyclones with a 10 µm cut-size.

For measuring aerosol size distributions, two parallel scanning mobility particle sizers (SMPS) were used. In addition, there was a TEM collector and an electrical low pressure impactor (ELPI), with which the sample could be led straight to the inlet or through a differential particle sizer (DMA). The latter case enabled a measurement of monodisperse aerosol and different particle sizes with the ELPI. Comparing the mobility diameter calculated from the DMA settings and the aerodynamic diameter calculated from the ELPI data, the effective density of the particles could be defined.

Results

The aerosol size distribution measurements showed that particles in the sub-500 nm size range mainly form two modes. The smaller mode exists with higher concentrations at the superheater but is also seen at the 2nd pass of the boiler. The larger mode is more stable and the concentrations are closer to each other at different measurement locations. According to the effective density measurements, the density of the smaller mode is around $1.4\,g/cm^3$. The larger mode has much higher density and it seems to obey core-shell like density as a function of particle size.

The results indicate that the larger mode exists already in the boiler. In the dilution, gas phase components condense on the existing particles and form new particles through nucleation. This results in a new mode of particles, referred before as the smaller mode, and core-shell structures in the larger mode. The effect of ferric sulphate as fuel additive is seen in decreased particle concentration especially in the smaller mode. Also the density values of these particles are slightly lower.

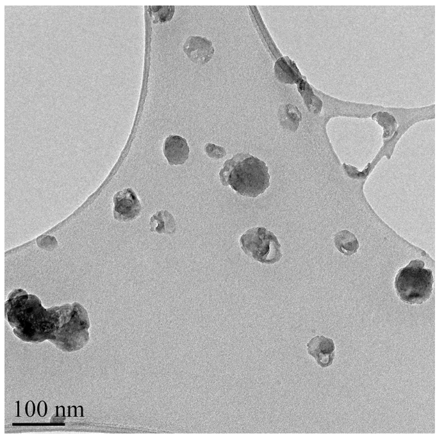

Figure 1: A TEM image of some collected particles.

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