

CHALMERS

CHARACTERISATION OF PARTICLE EMISSIONS FROM SMALL-SCALE BIOMASS COMBUSTION

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ABSTRACT

Several studies have shown that particulate air pollution is associated with increased mortality. Combustion devices like boilers and internal combustion engines are important sources of particles in the ambient air. In Sweden, the combustion of biomass is increasing and may consequently lead to locally increased particle concentrations. Roughly spoken, particles from biomass combustion consist of ash and of particles originating from incomplete combustion. Several studies of emissions of particles from biomass combustion have been performed, but the particle formation mechanisms are not yet fully understood. The purpose of the present work is to characterise particle emissions from small-scale combustion of wood pellets and wood briquettes, and to contribute with more data on the emission behaviour of biomass-burning boilers.

Particle emissions from a pellet stove, two pellet burners and two smaller biomass-fired district heating boilers were studied. Transient effects and influence of operating parameters, such as boiler load and excess air, were investigated. The district heating boilers were fired with wood pellets and wood briquettes and were equipped with multi-cyclones for dust removal. The particle emissions from the district heating boilers were measured downstream of the multi-cyclones. The particle emissions from the domestic heating devices were sampled in the chimney. Number concentrations and number size distributions were determined using an ELPI (Electrical Low-Pressure Impactor). In a few cases an ELPI was operated simultaneously with a SMPS (Scanning Mobility Particle Sizer) to analyse number concentrations and size distributions. Mass concentrations were measured by weighing of collected dust on filters according to Swedish standard. Mass size distributions were determined by a DLPI (Dekati Low-Pressure Impactor). In a few cases analysis of particle composition was carried out with focus on inorganic components. EDX (Electron Dispersive X-ray) analysis identified the main components. A new method to analyse the mass and molar fractions of alkali compounds, based on TOF-SIMS (Time-of-flight Secondary Ion Mass Spectrometry), was developed. CO, CO₂, O₂, THC (total hydrocarbons) were recorded in all cases, to give information about the combustion conditions. In most cases the NO_x-emission was recorded as well.

Mass concentrations of particles varied from 65 mg/m³ dry flue gas from the pellet stove to 84 mg/m³ dry flue gas for the district heating boiler fired with pellets, both emissions normalised to 10 % O₂. Number concentrations (30 nm - 10 µm) were in the range 10⁷ – 10⁸ cm⁻³. The particle emissions were dominated by submicron particles (particle diameter < 1 µm), both from number and mass perspective. The EDX analysis showed that the main inorganic components of the sub-micron particles were potassium, sulphur, chlorine and oxygen. Smaller amounts of sodium, magnesium and zinc were also found. Potassium sulphate was the most common compound and the second most common was potassium chloride.

Keywords: particle emissions, biomass combustion, domestic heating, district heating