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INTRODUCTION

The use of biomass for heat and energy generation is being strongly promoted in order to fulfil the EU White Paper objectives to double the share of renewable energy sources in the Union's energy production by 2010 (White Paper, 1997). Although a strong concern arises about biomass combustion impacts on environment and human health as these are not fully investigated nor understood. Recently many research groups have shown an increased interest in this area (T. Nussbaumer, 2001). There is a growing concern about fine (<2.5 μm) and ultrafine (<0.1 μm) particles, as a significant part of the particles generated during biomass combustion is within this size range. These particles have long residence time in the atmosphere and may be associated with adverse health effects due to their penetration and deposition in the lower respiratory tract and their enrichment of potentially harmful components (e.g. heavy metals). Therefore the aim of this study was to characterise particle emissions from biomass combustion and gain better understanding of mechanisms governing particle formation processes and particles' physical and chemical properties. Particle emissions from 1 and 6 MW commercial biomass fired boilers were studied. Both boilers are situated in southern part of Sweden. The boilers are of moving grate type and operate using moist forest residues as fuel (water content 30-55 % mass). The only abatement measure in 1MW boiler is a multi-cyclone. The 6MW boiler is equipped with a multicyclone, electrostatic precipitator (ESP) and condensing gas cooler.

METHODS

For the comparative purposes the flue gas was sampled after the multicyclone in both units. The flue gas was diluted (1:20) and cooled to room temperature using particle-free dry compressed air. After dilution the flue gas passed a cyclone with a cut off particle diameter of 10 μm (d_{50}). A scanning mobility particle sizer (TSI SMPS 3934 - for particles in the 0.015-0.8 μm size range) and an aerodynamic particle sizer (TSI APS 3320 – for 0.5-10 μm) were used to measure the concentration and particle size distributions in near-real time. Parallely for mass size measurements a Dekati 13 stage multi-jet low pressure cascade impactor (LPI) was used. Additionally for the purpose of chemical analysis a stacked filter unit dividing the aerosol into a fine and a coarse fraction was used. Substrates from low pressure impactor and filter unit were analysed by PIXE (Particle-Induced X-ray Emission Analysis) (W. Maenhaut and K. G. Malmqvist, 1992). and IC (Ion Chromatography).

CONCLUSIONS

The total number concentrations (normalised to 13% CO_2 and NTP) of emitted particles after multicyclone with diameter smaller than 0.6 μm for 1MW and 6 MW boilers were $4.8*10^7$ and $4.4*10^7$ particles/cm^3, respectively. For particles with aerodynamic diameter greater than 0.9 μm, concentrations for 1 MW and 6 MW boilers were 2200 and 6600 particles/cm^3, respectively. Comparison of number size distributions measured in SMPS and APS range for both boilers show very good agreement as shown in Figures 1 and 2. The geometrical mean diameter of the fine particle mode was 93 nm for 1 MW boiler and 88 nm for 6 MW one. Much bigger fluctuations in the coarse mode (1-10 μm) number concentration over time were observed in 1 MW boiler (between 100 and 10000 particles/cm^3) than in 6 MW boiler (between 6000 and 11000 particles/cm^3). Observed fluctuations in fine mode were much lower between $3.0*10^7 - 5.5*10^7$ in 1 MW boiler and between $3.7*10^7 - 5.5*10^7$ in 6 MW boiler.

Results obtained from PIXE analysis indicate that main elements (Z>12) in the fine particle fraction were K, S and Cl. Main elements in the coarse fraction were Ca, K, S and Cl. No significant differences in particle elemental composition between the two boilers were observed. IC analysis of water soluble ions shows that K^+ accounts for 72 and 75% of analysed ions for 1 MW and 6MW boiler respectively, SO_2^{4-} accounts for 17% in both cases, Cl^- for 5 and 7% and Na^+ for 3 and 1% (for 1 MW and 6 MW boiler respectively). Results from IC analysis agree well with those from PIXE, the results can also suggest that the coarse mode particles were generated as an insoluble (Ca-rich) core onto which water soluble volatilised species condense.

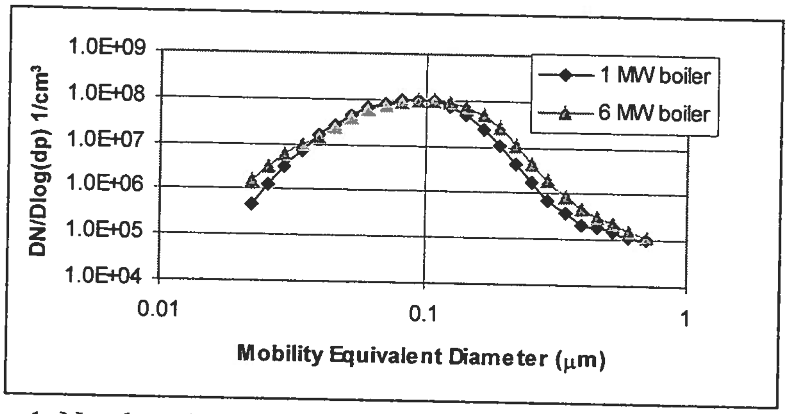

Figure 1. Number size distribution within SMPS range for two boilers.

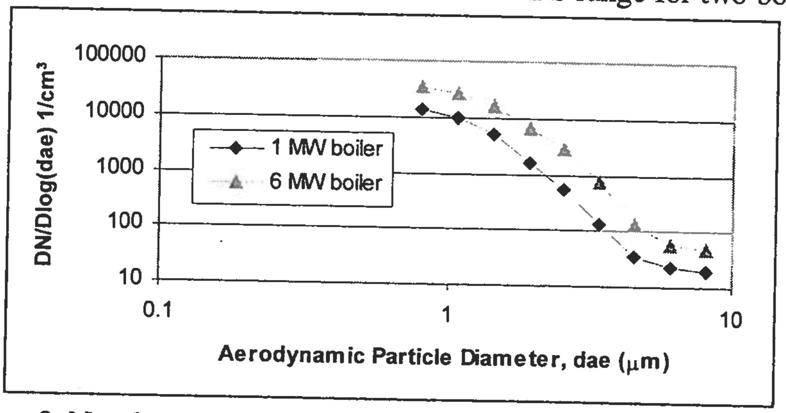

Figure 2. Number size distribution within APS range for two boilers.

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