FTIR flue gas measurements in industrial combustion plants generating heat and power

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1 Introduction

Biomass fired power generation has been widely investigated and gaseous emissions formed in the combustion process have been under intensive study especially in fluidized bed boilers. Pollutants from combustion units can be classified as pollutants from incomplete combustion like CO and C_xH_y and pollutants produced by combustion including ash, nitrogen, sulphur etc. Pollutants produced by combustion are formed depending on the fuel used. Pollutants caused by incomplete combustion are due to too low combustion temperature, poor mixing, and too short residence time in the furnace. (Bain et al. 1998, Demirbas 2005, Grass et al. 1994, Jenkins et al. 1996, 1998, Khan et al. 2009, Winter et al. 1999, Yin et al. 2008)

2 Objectives of the research

Flue gas emission measurements from the combustion of biomass are one part of a project "Novel way to control the combustion of various biomasses", funded by the Academy of Finland. The project is carried out in co-operation with The Department of Process and Environmental Engineering and The Department of Chemistry and it is dealing with the problem of slagging and fouling of inner surfaces of the boiler in biomass combustion.

This paper presents the results of the first two flue gas emission measurements done during the project. Formed gas emission components are identified and quantified and special focus is laid on sulphur-, nitrogen- and total hydrocarbon emissions. The combustion plants investigated in this research were a small 2.5 MW district heating plant with a grate boiler using peat as a fuel and a 315 MW power plant with a circulating fluidized bed using a peat and wood mixture as a fuel for heat and power generation. Particle matter (PM) formed in the combustion was also collected and measured from the flue gases.

3 Experimental

The measurements were performed with Gasmet Dx-4000 FTIR (Fourier Transform Infrared Spectroscopy). FTIR is used in demanding emission measurements since it is a sensitive, fast and continuous measurement technique. The measurements at both combustion units were carried out in two consecutive measurement days and the measurements were done after the flue gas cleaning system of the boiler. The particulate matter was collected with the STL-Medi collection system and analyzed according to the SFS 3866 standard.

4 Results

4.1 Gaseous emissios

Figures 1 and 2 presents the average NOx-, THC- and SOx-emissions from the two investigated boilers. These results are calculated from the concentrations measured; and NOx includes NO and NO_2, SOx includes SO_2, SO_3, CH_4S, C_2H_6S and $C_2H_6S_2$, and THC includes CH_4, C_2H_4, C_3H_8, C_4H_{10}, C_2H_6, CH_4O, C_2H_6O, C_6H_{14}, CH_2O and CH_4O.

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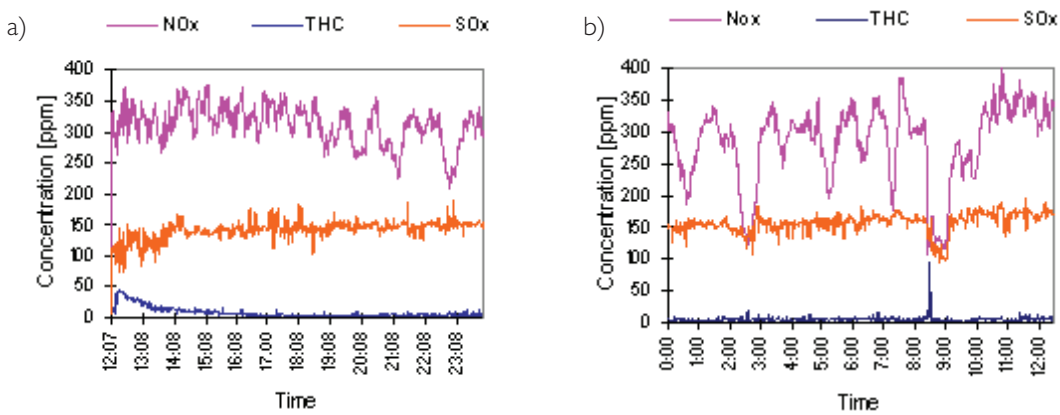

Figure 1 *NOx-, THC- and SOx-emissions from grate firing peat on a) measurement day 1, b) measurement day 2.*

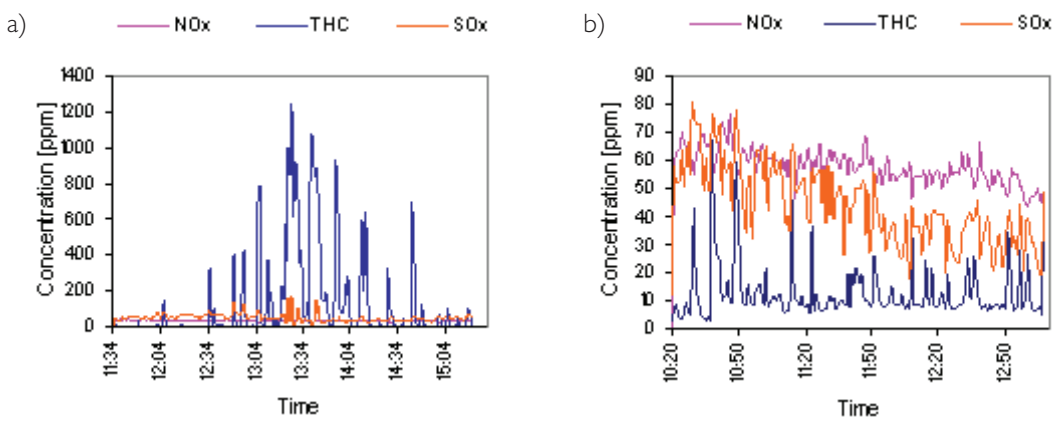

Figure 2 *NOx-, THC- and SOx -emissions from combustion of peat and wood mixture in the circulating fluidized bed boiler on a) measurement day 1, b) measurement day 2.*

In Figure 1, the differences between the measurement days are due to the operation problems of the boiler. From the Figure 1b it can be clearly seen that the combustion unit had a small shut down after eight o'clock and this can be seen also from the THC figure where the THC concentration has risen to ~100 ppm. This TCH peak mostly contains methane and only small amounts (<5 ppm) of other TCH compounds.

Operation problems cause the THC concentration to rise also in the fluidized bed boiler (Figure 2) on measurement day 1. NOx and SOx concentrations stay at both measurement days below 100 ppm, but the TCH concentration (mostly methane) raises to higher concentrations. On the second measurement day THC concentration stays under 70 ppm during the measurement.

4.2 Particle emissions

Particle emission measurement results are presented in Table 1.

Table 1 *Particle emissions from the fluidized bed boiler and from the grate boiler.*

		measurement day 1	measurement day 2
Fluidized bed boiler:	kg/h	0.25	0.18
Grate boiler:			
Sample 1	kg/h	0.324	0.278
Sample 2	kg/h	0.403	0.453
Sample 3	kg/h	0.298	0.327
Sample 4	kg/h	0.456	
Average	kg/h	0.456	0.353

The average particulate matter in flue gases for fluidized bed boiler was 0.215 kg/h and for grate boiler 0.405 kg/h. This shows the operation of a significantly more effective gas cleaning system of the fluidized bed boiler even though the capacity of the boiler is substantially higher compared to the grate boiler. In the grate boiler the flue gases are treated in a cyclone and in the circulating fluidized bed the flue gases are treated in an effective cleaning system including flue gas scrubber and an electric filter.

5 Relevance of the research

The properties and composition of the fuels vary and therefore the properties of the ash vary as well. The combustion of different biomass fuel-mixtures easily results in a growing deposition of ash on the inner surfaces of the boiler if the mixtures of fuel or the process conditions are not optimal. After that the heat transfer capacity of e.g. the superheaters declines due to insulating effects and also corrosion may occur. Therefore, suitable methods are needed to prevent fouling and slagging. Applying new measurement methods and modeling and by gaining information from fuel, ash, slag and flue gases, fouling and slagging may be monitored and controlled remarkably better. It is believed that by information achieved with sensitive measurements the phenomena of slagging and fouling may be revealed better and the deposition of ash before it starts to affect the performance of the boiler may be observed and later on controlled.

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