To be presented in the International Aerosol Conference 2010, Helsinki 29.8 – 3.9.2010

Fine particle and gas emissions of a novel pellet burner based on gasification combustion

Nuutinen, Ilpo[1], Sippula, Olli[1], Tissari, Jarkko[1], Jokiniemi, Jorma[1,2]

[1]Department of Environmental Science, Fine Particle and Aerosol Technology Laboratory, University of Eastern Finland, P.O. Box 1627, FI-70211, Kuopio, Finland
[2]VTT Technical Research Centre of Finland, Fine Particles, P.O. Box 1000,FI-02044 VTT, Espoo, Finland

Keywords: fine particles, emissions, gasification, pellet, burner, combustion

In Finland still over 240 000 households are heated by oil. Reaching European Union's target of 20% renewable energy of total energy consumption in 2020 requires vast changes also to household heating systems. One solution to increase usage of renewable energy is to convert present oil heating boilers to use wood pellets. Still proliferate of biomass burning has raised public concern over health effects of the produced fine particles. Fine particle emissions of currently modern pellet appliances are in the range of 10-20 mg/MJ (Tissari *et al.*, 2008, Lamberg *et al.*, 2009). These pellet fired burners and boilers burn their fuel directly on a burning head or on a fixed grate. As an option to reduce harmful emissions, combustion air staging has been shown to influence remarkably the formation of fine particles in small pellet appliances (Lamberg *et al.*, 2009). First, optimised air staging enhances the burnout of soot and organic material. Second, air staging can be used to reduce temperature in the fuel bed which decreases formation of fine fly ash particles. Thus, highly-staged combustion (gasification combustion) of biomass has been shown to generate clearly lower emissions than traditional grate-firing (Sippula *et al.*, 2009).

Fine particle and gas emissions of a novel 15 kW fixed-bed updraft gasifying pellet burner (Pyro-man) based on gasification combustion were studied. The computer aided burner first gasifies the fuel with a controlled amount of air and then burns the product gas in a separate burner head with two-staged air supply. The burner was installed in a boiler system with heat exchanger circuit, flue gas duct and a stack. The draft in the flue gas duct was controlled by using a draft regulator. The burner was operated with nominal output using good quality wood pellets. Fine particle emissions were measured with a diluting sampling system described in Tissari *et al.* (2008). Fine particle mass emissions (PM1) were determined by collecting filter samples from diluted flue gas. Electrical low pressure impactor (ELPI, Dekati Ltd.) and Fast mobility particle sizer (FMPS, TSI Inc.) were used to measure particle number concentrations and size distributions. The PM1 filter samples were analyzed for metals (ICP-MS), anions (Ion chromatography) and organic and elemental carbon (Thermal-optical method). Gaseous emissions were measured with an FTIR multicomponent analyzer.

The average flue gas O_2 concentration was 8.0 % during the measurements. The average PM1 emission was 2.4 mg/MJ, CO emission 6.1 mg/MJ, and particle number emission 1.8×10^{13}/MJ. Figure 1 shows the particle number size distribution and chemical composition of PM1.

The studied pellet burner was found to generate very low fine particle emissions when compared to currently typical pellet appliances. The CO, organic material and elemental carbon (soot) emissions were also low, showing high combustion efficiency. Thus, the fine particles were formed mainly of ash material. In addition, due to the low temperature in the fuel bed, lower amounts of alkali metals are released than in traditional grate-firing. Furthermore, the fine particles were smaller in size than typically observed from pellet appliances.

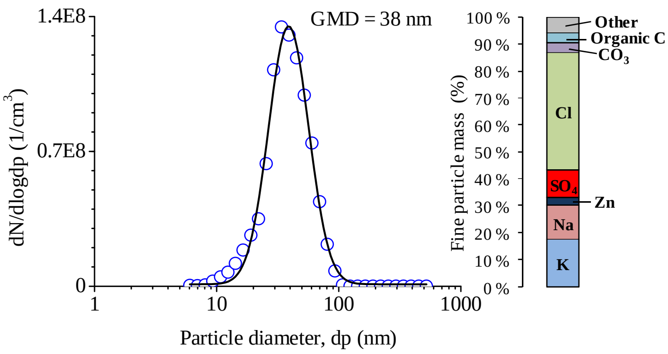

Figure 1. Particle size distribution (FMPS) and PM1 chemical composition.

The results show that the gasification combustion technology can be used to achieve very low fine particle and gas emissions also in small-scale biomass combustion.

This work was supported by the Finnish Funding Agency for Technology and Innovation.

Tissari, J., Sippula, O., Kouki, J., Vuorio, K., Jokiniemi, J. (2008). *Energy & Fuels* 22, 2033-2042.

Lamberg, H., Sippula, O., Tissari, J., Jokiniemi, J. (2009). *4th International Bioenergy Conference.* Book of Proceedings. Part II. 31.8-4.9.2009, Jyväskylä, Finland, 667-672.

Sippula, O., Hokkinen, J., Puustinen, H., Yli-Pirilä, P., Jokiniemi, J. (2009). *Energy & Fuels* 23, 2974-2982.