BRNO UNIVERSITY OF TECHNOLOGY

Experimental Investigation of Concentration and Size Distribution of Fine Combustion Particles Emitted by Small Biomass Boiler under Various Operation Conditions

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Introduction

This poster deals with the experimental identification of concentration and size distribution of fine combustion particles emitted by domestic biomass combusting boiler. The poster presents a testing procedure of real biomass boiler with detail monitoring of the concentration and size distribution of emitted particles PM_1.

Setup and measurement

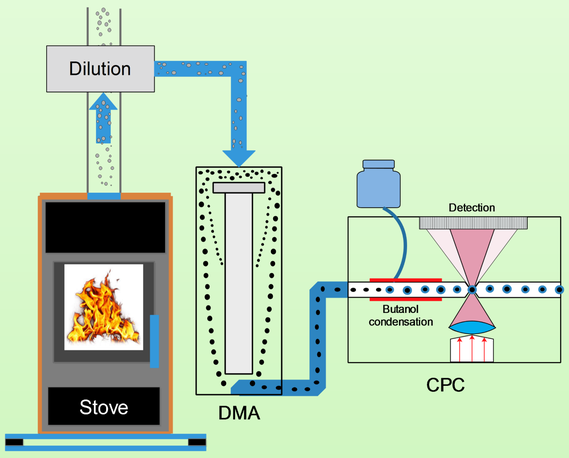

Fig. 1 The PM_1 measurement setup scheme: DMA - Differential Mobility Analyzer; CPC - Condensation Particle Counter

- The SMPS (Scanning Mobility Particle Sizer)
- A number of particles is identified by the Condensation Particle Counter (CPC)
- The mass flow of the flue gas sample continuously taken for subsequent analysis was 0.3 l/min.
- The sampling was carried out using an isokinetic probe inserted in the centre of a circular flue gas duct.

- The 20kW Ekoscroll Alfa automatic pellet boiler.
- Made by Ekogalva, s.r.o.
- Emission Class: 5 / (A+)
- A sample of the flue gas was continuously taken from the chimney to the SMPS
- The chimney diameter: 120 mm

Fig. 2 The tested EKOSCROL boiler connected to the measuring equipment

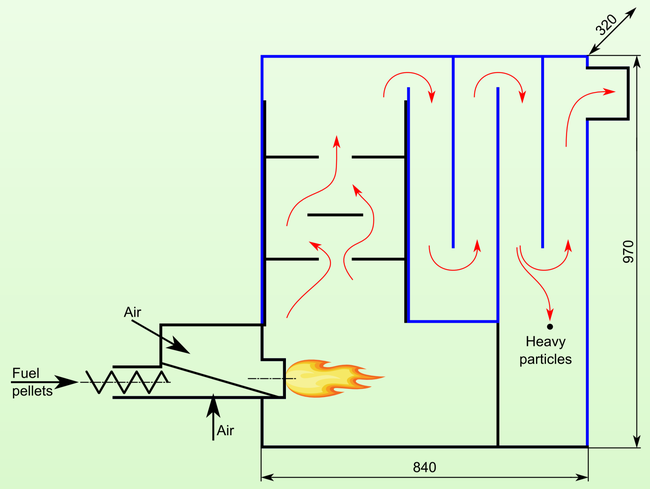

Fig. 3 The geometry of the inner space of the boiler

- Burner with a controlled amount of primary and secondary air flow
- Flue gas temperature: up to 1200 °C.
- Transfers thermal energy to the cooled heat exchange surfaces through radiation and convection.
- The temperature of the heat exchange surfaces is close to 80 °C.
- The temperature of the flue gas leaving the boiler is 140 °C.
- The chimney diameter: 120 mm

Tested fuel pellets properties

Fig. 4 The Spruce-pellets (left) ant the agro-pellets were formed from waste agricultural biomass (right)

Table 1 Properties of the tested fuel pellets

Fuel	Size [mm]	Humidity [%]	Combustion heat [MJ/kg]	Content in flue gas		
				NO [mg/m³]	CO [mg/m³]	O_2 [%]
Agro-pellets	7-8	7.6	16.96	77	63.9	11.3
Spruce-pellets	8-10	11.03	16.96	350	27.3	9.3

Results

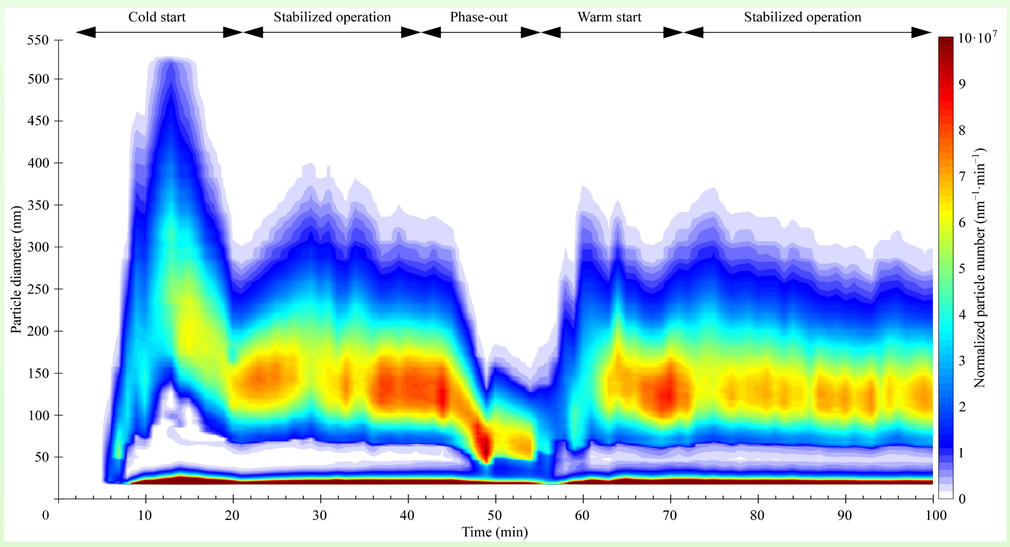

Fig. 5 The development of concentration and size distribution of FP in flue gas; Spurce-pellets

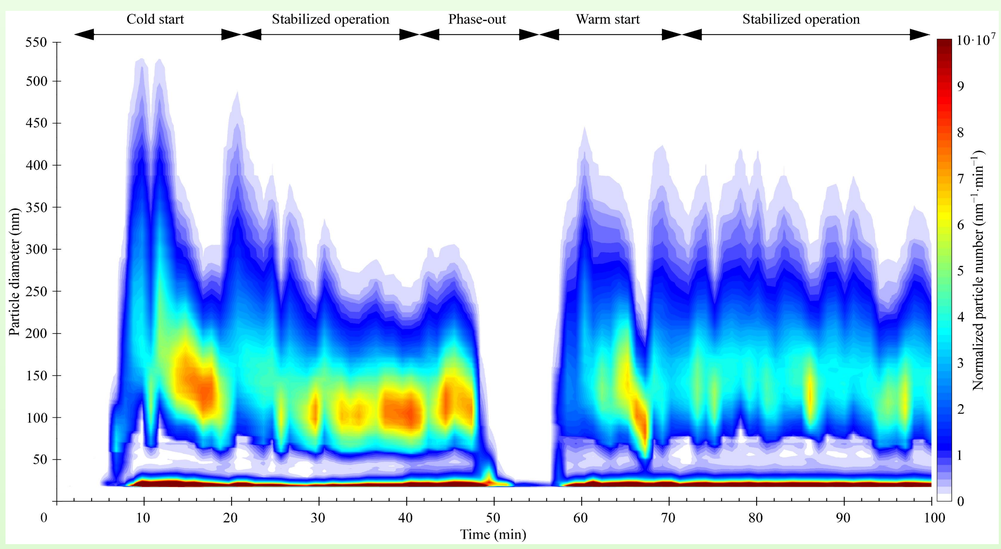

Fig. 6 The development of concentration and size distribution of fine particles in flue gas; agro-pellets

- A sequence of various operating conditions which regularly occur during a normal operation of the boiler was designed:

  - *cold start of the boiler,*
  - *steady operation of the boiler with rated burner parameters,*
  - *combustion attenuation,*
  - *warm start of the boiler,*
  - *a steady operation with rated burner parameters,*
  - *boiler extinction.*

The sample analysis has been performed by Scanning Electron Microscopy (MIRA3, Tescan, Ltd.):

- start of process - particles 1 – 400 nm,
- detected elements: C, O, Si, Na, K, Zn, S, P.

The presence of some elements may be caused by the contamination of the pellets.

For the human health risk assessment are important:

- morphology (problem of 2D visualization of SEM)
- physicochemical properties,
- concentration and amount.

The effectiveness of deposition in the human respiratory tract:

- 1 - 100 nm particles - tracheobronchial area (trachea, bronchi, bronchi, pulmonary alveoli)
- 1 - 10 μm are mainly extrathoracic areas (non-thoracic)

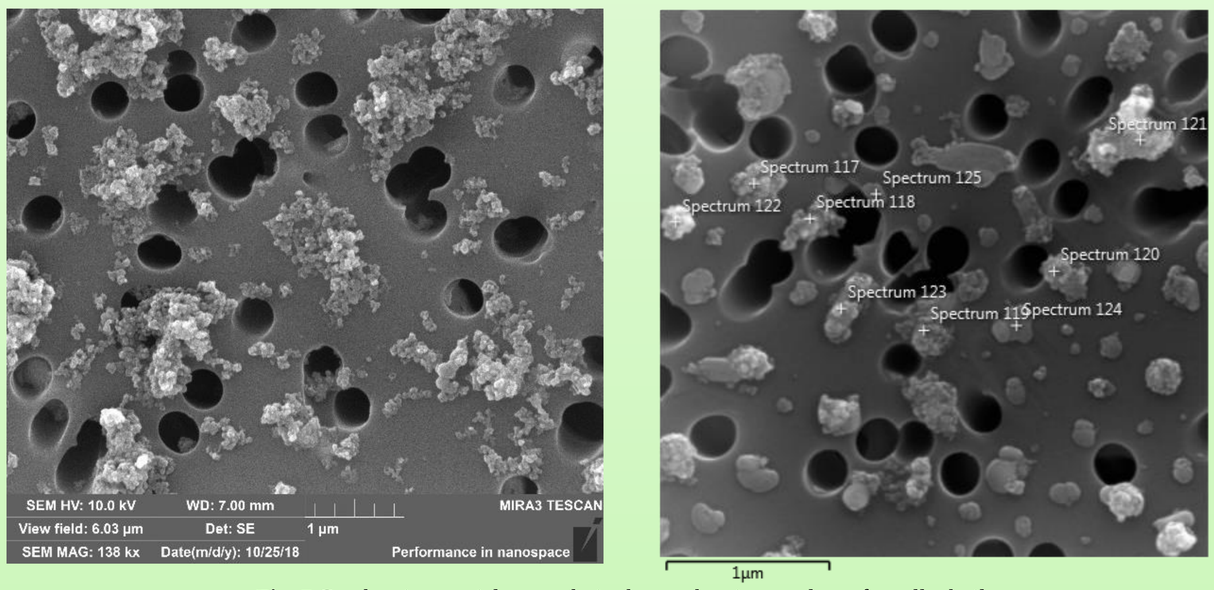

Fig. 7 Combustion particles cought in the combustion product of a pellet boiler

Fig. 8 The time development of the number of fine particles generated

Conclusions, summary

- To reduce the production of fine particles during biomass combustion it is crucial that the surface temperature of the combustion chamber walls is sufficiently high.
- In a heated combustion chamber a smaller number of particles are formed than in a chamber with cold walls.
- During the ignition of fuel in a heated chamber there is significantly lower production of fine particles compared to a cold start.
- During combustion in a well heated combustion chamber only a slight difference in the production of fine particles was observed using various fuel pellets.
- The production of fine particles is greater when using agro-pellets (produce 30% more particles on average during all the tested operating conditions)
- The difference is especially apparent in the cold start period and during the subsequent steady burner operation.
- After heating the uncooled surfaces of the boiler to 200°C, the difference between spruce-pellet and agro-pellet combustion diminishes.

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