NANOPARTICLES EMISSION FROM SMALL OUTPUT COAL-FIRING FURNACES

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Introduction

- engineered and non-intentionally produced nanoparticles
- solid fuel burning combustion systems
- nanoparticles can have a strong impact for human health

The production of both engineered and non-intentionally produced nanoparticles has been recognized as an important source of air contamination. The number of types and the quantity of aerosol containing nanoparticles have increased significantly. The investigation of possible health effects of nanoparticles has started recently and nowadays it is a subject of concern of several research projects. Nevertheless, the study of health effects is complicated and still in early stages and this is why the precautionary principle should be applied in public health consideration related to nanoparticles. Solid fuel burning combustion systems produce emissions, which are of concern to authorities and public. It is already known that fine particles in emission have long residence time in the atmosphere and according to many authors they are associated with adverse health effects due to their penetration and deposition in the lower respiratory tract and their enrichment by potentially harmful components (e.g. heavy metals, PAHs). Nanoparticles can have strong impact for human health (negative influence of cardiovascular and respiratory system). The respiratory system is the easiest way for entry of nanoparticles to a human body where they can be toxic and have fibrogen impact. These days we talk about mutual interaction between these fine particles and DNA, RNA and proteins in connection with emissions and nanoparticles production.

Experimental methods

- nanoparticles after optimization of burning process in automatic boiler
- complication with character of fine particles and their mutual interaction and different behaviour
- particular nanoparticles aerosol fractions concentration measured by FMPS 3091 spectrometer

Measuring of nanoparticles from burning process represents not easy task because it is demanding on experimental equipment and measuring performance (general overview and attention to detail). In small output furnaces it is very difficult because of complications associated with the measurement of nanoparticles are combined with the difficulties of measurement of small output furnaces. These complications are caused by character of the fine particles and possibility of their mutual interaction and their different behavior from common TSP, their high concentrations in exhaust gases and after that necessity of using series exhaust gases dilution, complexion composition of mat (emission) including risk of liquid phase condensation and necessity of emission conversion to standard condition (content of oxygen). The most frequent is dilution by filtered atmosphere air. The problem is homogeneity of dilution mixture and the question of nanoparticles separation by coagulation or adsorption on the measuring track wall. In this experiment we are focused on determination of nanoparticles distribution emerging after burning optimization in the automatic boiler C-100 (output 100 kW). As the fuel was used brown coal. During the burning process the boiler was set on 90 kW output. Frequency of fuel batch was 15 seconds (15 seconds batching, 15 seconds delay). Measurements were performed by 10 % referent content of oxygen. Fig. 1 shows experimental equipment. One of the aims was the evaluation of nanoparticles concentration by measuring track. Dilution was used for another diluter (Fig. 2). The resulting dilution factor was adjusted by the flow rate of the filtered diluting air and the flow from dilution tunnel. Dilution in tunnel was 1.7 and dilution rate in diluter was 1:123. The particular nanoparticles aerosol fractions concentrations in the range 5 to 250 nm were measured by FMPS 3091 spectrometer.

Fig. 1 Experiment – nanoparticles analysis

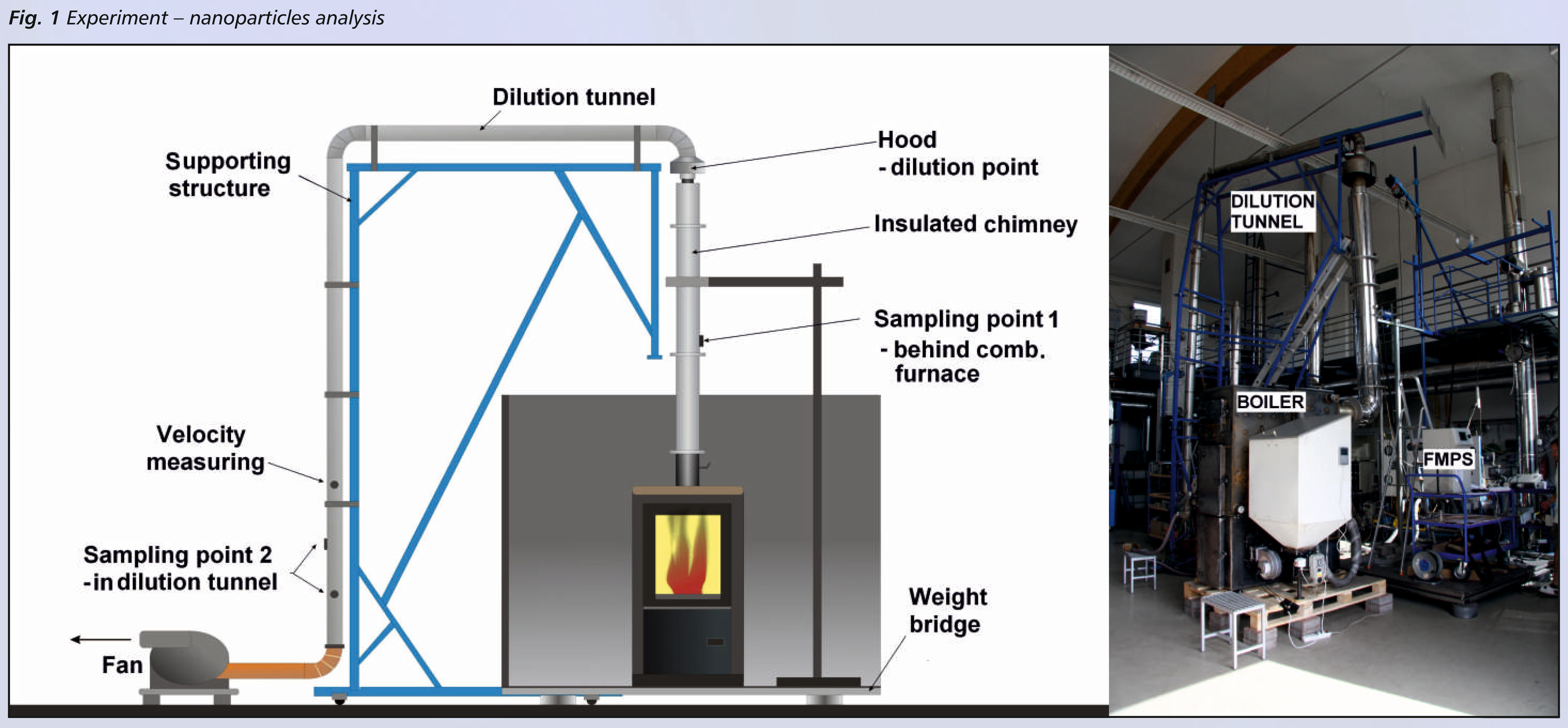
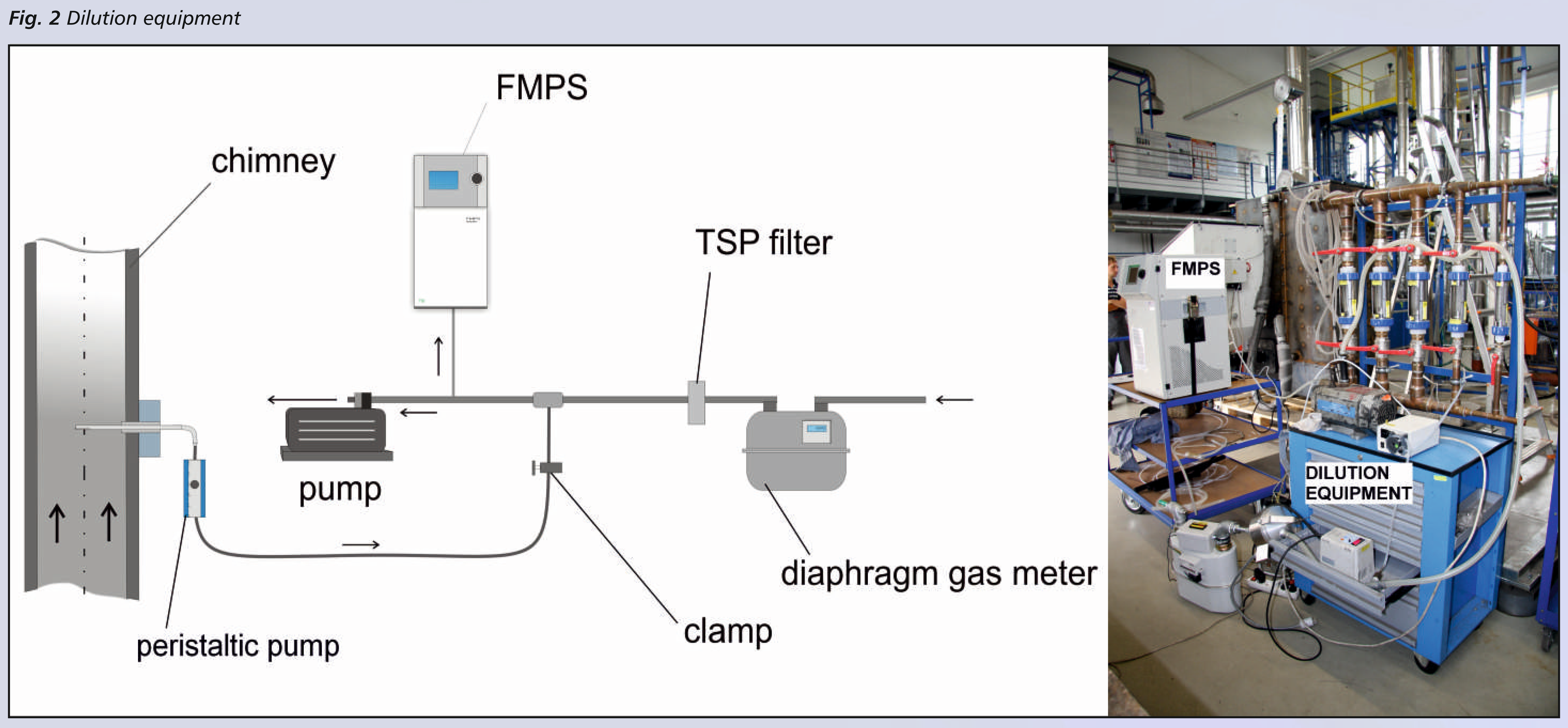


Fig. 2 Dilution equipment



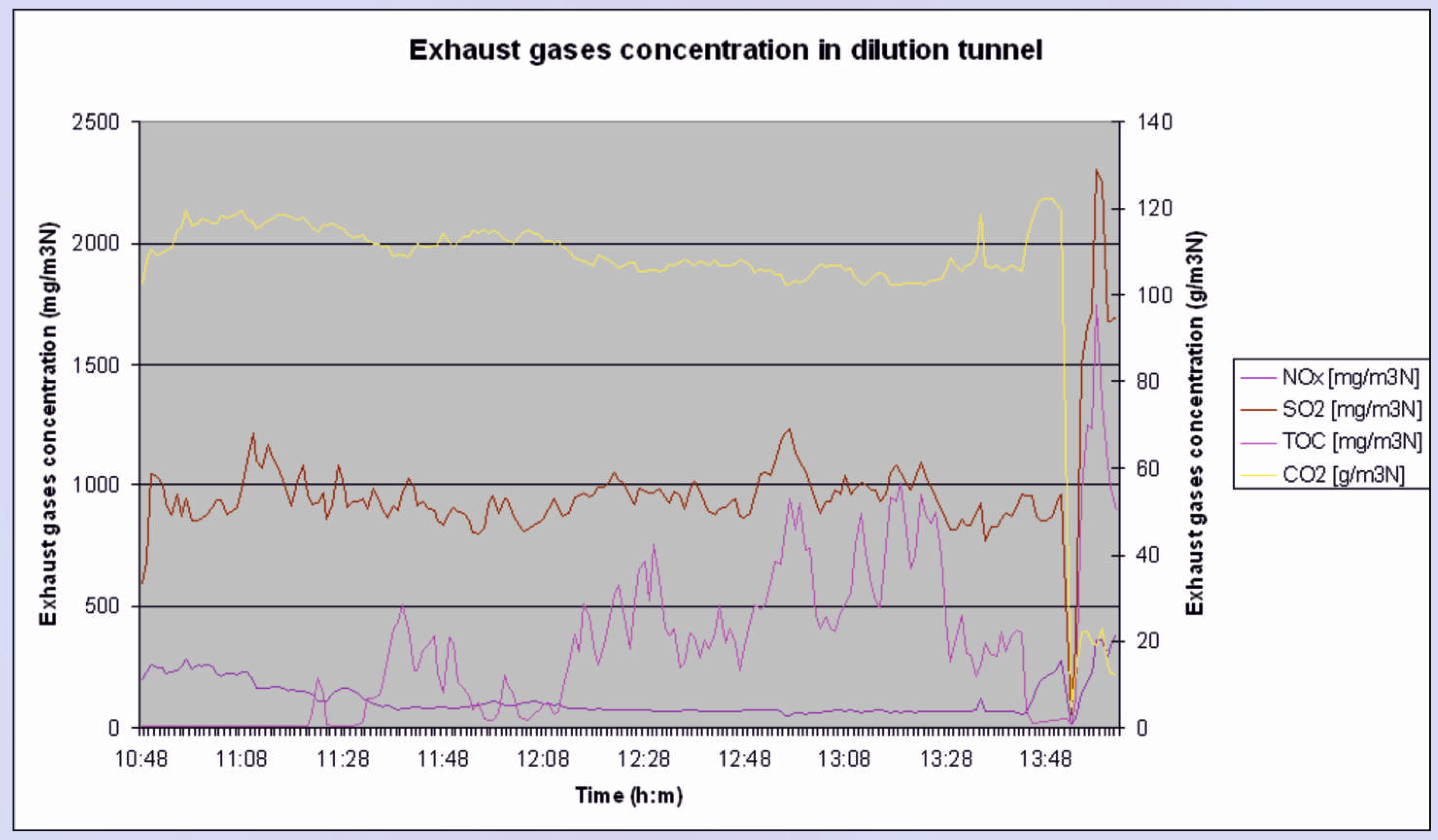


Fig. 3 Exhaust gases concentration in dilution tunnel

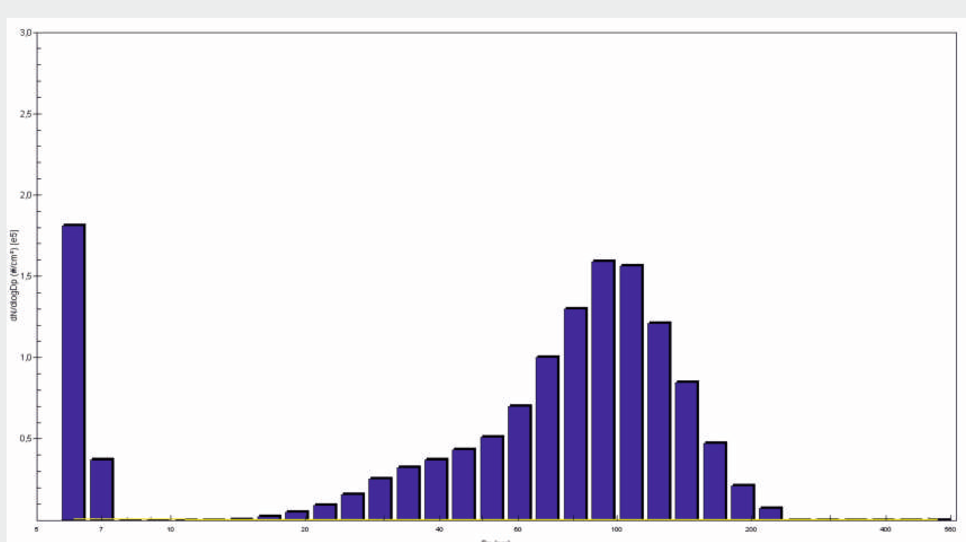


Fig. 4a

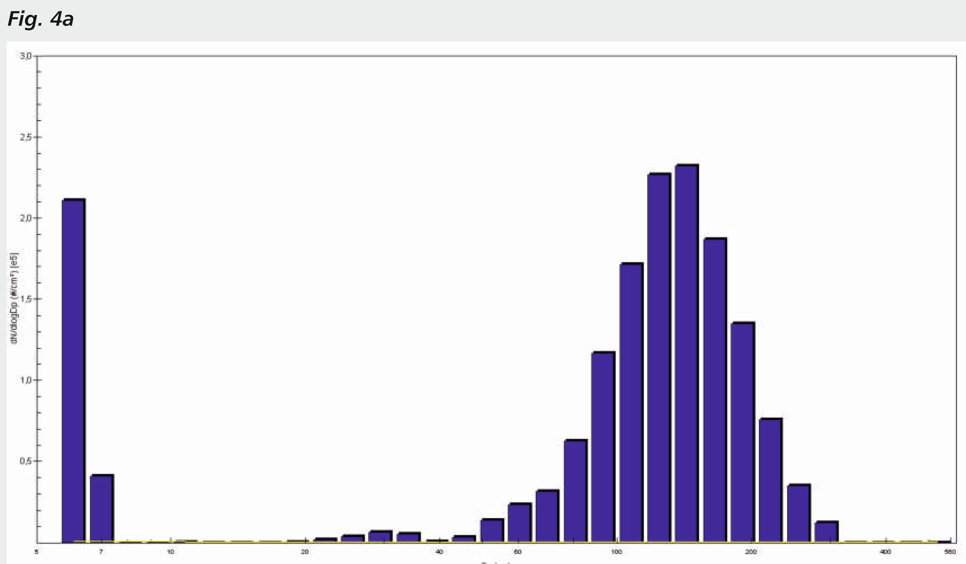


Fig. 4b

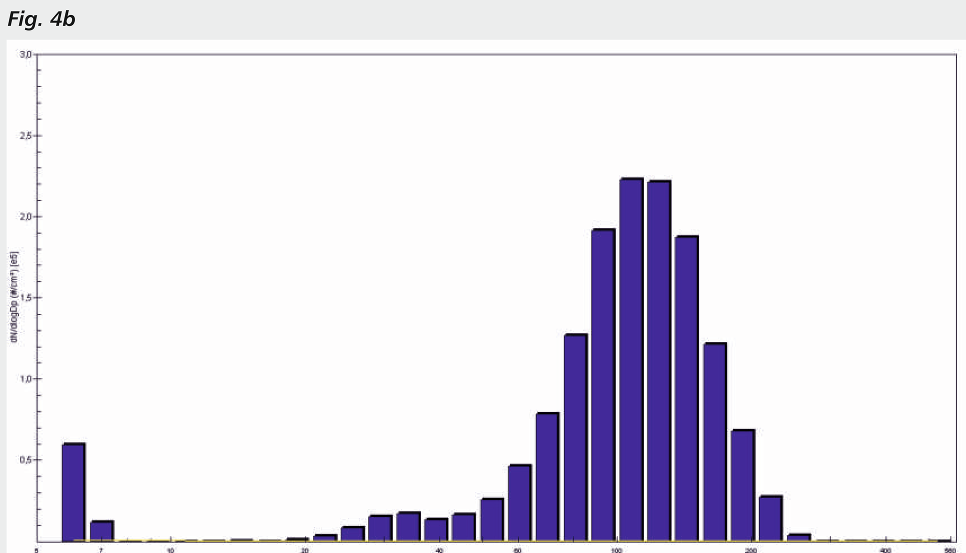


Fig. 4c

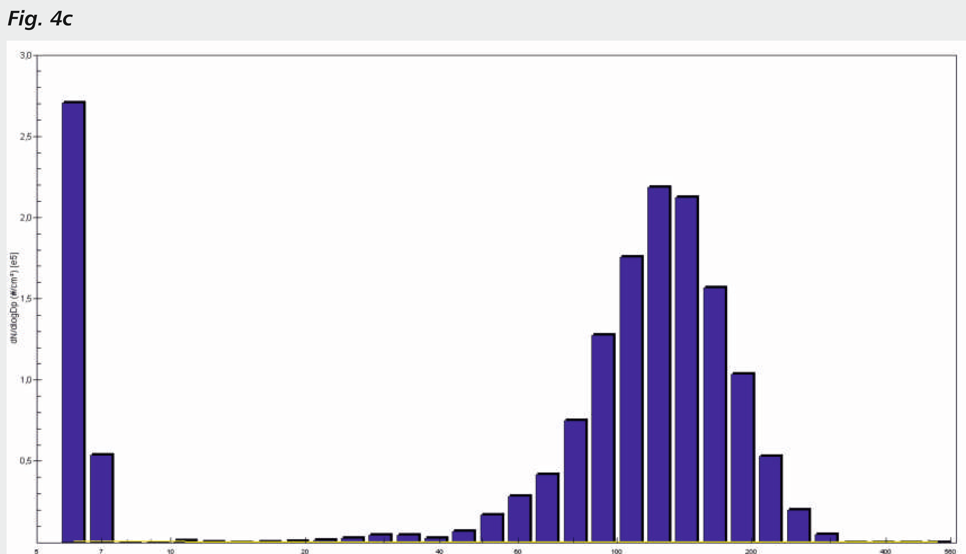


Fig. 4d

Fig. 4 Histogram of nanoparticles distribution from sampling point 1 (Bs5, Fig.4 a,b) and sampling point 2 (DTs2, Fig.4 c,d) during switch on fuel dispenser and switch off fuel dispenser

Results

- the most representation is nanoparticles under 6 nm and in range 60 – 200 nm
- on cross profile of sampling points nanoparticles are not distribute homogenous
- length of silicon tube has impact on nanoparticles concentration

On the base cross profile analysis in sampling points was found that concentration of nanoparticles is not uniform but is higher from one edge to another. This phenomenon is stronger in sampling point 1, it can be explained by better mixed exhaust gases with the air in dilution tunnel. Total particle concentration converted to standard content of oxygen and normal conditions was in range $5.06.10^{6}$ to $6.25.10^{6}$ #/cm^3 (sampling point 2). Similar exhaust gases distribution was measured on sampling point 1. Total particle concentration was in range $9.13.10^{6}$ to $1.32.10^{7}$ #/cm^3 (Tab. 1). The particle concentration was influenced by the length of silicon tube. On sampling point 2 exhaust gases were taken by shorter silicon tube (1.5 m) (DTs1a, DTs2a, DTs3a) what had impact on nanoparticles concentration (triple loss of particles on inner tube surface). The modus was approximately the same in both cases. During fuel batching the nanoparticle distribution and concentration was similar, only the concentration of the smallest fraction was strongly higher. The cause of this phenomenon is not still clear (Fig. 4). As emerged from histograms the most are represented nanoparticles under 6 nm and in range 60 – 200 nm.

Tab. 1 Exhaust gases in sampling points 1 and 2, total concentration of particles and modus

Boiler		Output	CO	NOx	SO2	TOC	CO2	Total concentration (dN/dlog Dp)	Modus (the most frequent fraction)
		[kW]	[mg/m3N]	[mg/m3N]	[mg/m3N]	[mg/m3N]	[g/m3N]	[#/cm3]	[nm]
Sampling point 1	B s4	87	77.95	0.46	7.11	5.24	0.73	1.37E+07	6 ; 124
	B s5	86	80.21	0.52	8.38	7.17	0.84	1.32E+07	6 ; 143
	B s6	85	76.15	0.57	7.71	6.61	0.84	9.13E+06	6 ; 130
Sampling point 2	DT s1a	91	15.03	0.81	6.9	0.6	0.92	1.57E+07	6 ; 93
	DT s2a	89	30.85	0.66	7.34	2.21	0.89	1.75E+07	6 ; 107
	DT s3a	89	50.95	0.61	7.87	2.85	0.88	1.84E+07	6 ; 107
	DT s1	71	18.65	1.49	13.2	9.33	0.17	5.06E+06	6 ; 102
	DT s2	84	11.16	1.74	6.2	0.28	0.79	6.25E+06	6 ; 102
	DT s3	84	63.99	0.49	7.66	2.34	0.88	5.95E+06	6 ; 100

In sampling point 1 (before dilution tunnel) and sampling point 2 (in the end of dilution tunnel) were measured cross profile in 3 points (Bs4 – Bs5 and DTs1 – DTs3). Values from DTs1a – DTs3a were measured with shorter (1.5 m) tube. The histograms have two the most frequent fractions which are expressed by modus.

Discussion and conclusion

The experiment shows that during coal burning in automatic boiler mostly bigger nanoparticles (60 to 200 nm) are produced. The most frequent particles are nanoparticles about 6 nm. On cross profile of sampling points the nanoparticles are not distributed homogenously, nor on sampling point 2 (in the end of tunnel) where sufficient mixing with the air and homogenous distribution of particles was supposed. From comparison of the nanoparticles concentration sampling from two different places of dilution tunnel emerge that in the end of tunnel the particle concentration is approximately twice lower than behind boiler. This phenomenon shows that parts of nanoparticles are caught on the wall of dilution tunnel or they are coagulated. Active fuel batching has no influence on particle concentration but it increases concentration of the smallest fraction (6 nm). Measured data should be considered as relative to potential losses on measurement and dilution track.

Acknowledgement

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