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INDUSTRIAL PORTABLE FILTER TEST TECHNOLOGY WITH WIDE RANGE AEROSOL SPECTROMETER WRAS

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ABSTRACT

Filtration technology is used for many important applications. E. g. to avoid threats on human and public health, protect sensitive technical facilities and ensure high production standards. This work will show some new results and application examples of portable online wide range aerosol particle detection.

KEYWORDS

Air Cleaning, Air Filters, Filter test, Fine Particle, Nanoparticles Particle, Optical Particle Counter, Particle Measurement, Particle Size Distribution

Introduction

Air quality affects private and public health and the efficiency of industrial processing and manufacture! Therefore two main tasks are important to predict and avoid threats to human health and secure high technical production standards. Accurate dust measurements (indoor and outdoor) in a wide size range and precise monitoring and online quality assurance of mitigation techniques and filters.

The systems described in this paper are modular, portable, battery powered and robust. They allow particle detection and sizing in real time within a size range of 5nm up to more than 32µm. This so called Wide Range Aerosol Spectrometer (WRAS) offers a new possibility in online particle detection.

Materials and method

The Grimm aerosol spectrometer model 1.108 measures high particle concentrations up to 2.000 particles per ccm but also each single particle between 0,3 µm and 20 µm (optical latex equivalent diameter). The aerosol spectrometer classifies the particle size in 15 size channels and therefore better than many of the standards for filter testing requested. The sample is taken via our isokinetic sampler directly from the process. All detected particles are collected on a 47mm PTFE filter in the spectrometer for gravimetrical control or chemical analysis.

Table 1.: Specifications of Grimm Aerosol Spectrometer 1.108

Model	**Size range [µm]**	**Size channels [µm]**	**Particle range [particles/liter]**	**Dust range [µg/m³]**	**Application examples**
1.108 standard	0.3 to 20 15 channels	0.3/0.4/0.5/0.65/0.8/1/1.6/ 2.0/3/4/5/7.5/10/15/20	1 to 2.000.0000	0.1 to >100.000	Ventilation filter tester

The optical particle detection is based on 90° scattering light technique with a class 3B diode laser (= 780, P_{max} = 40 mW). The spectrometer is portable (2.5 kg with battery and internal pump) or AC powered. It is able to detect in real time particle number concentration or particle mass.

Filter testing from micro down to nano particles

In addition to the aerosol spectrometers for particles > 0.3 µm Grimm company also offers solution to count and classify particles down to some nanometers. For particle counting there are two different techniques the Condensation Particle Counter (CPC) model 5.403 and the Faraday Cup Electrometer (FCE) Model 5.700. Last system wont be described in this article. The CPC system is also portable and battery powered (or AC for stationary work). The classification of the nano particle size is realized due to their electrical mobility using a Differential Mobility Particle Analyser (DMA) Model 5.500. To cover all kind of nano particle applications there is a set of different DMA offered. Table 2 shows the specifications.

Table 2.: Specifications of Grimm nano particle device

Model	**Size range [nm]**	**Size channels [nm]**	**Particle range [particles/cm⁻³]**
5.500 m-DMA	5.5 to 350 (44 channels)	11.1/12.1/13.2/14.5/15.8/17.3/18.9/20.6/22.6/24.7/27/29.6/32.4/ 35.5/38.9/42.6/46.8/51.3/56.4/62/68.2/75.1/82.8/91.5/101.1/ 111.9/124.1/137.8/153.4/171.1/191.3/214.4/241/271.8/307.4/ 348.9/397.4/454.3/521/599.5/692.1/801.4/930.5/1083.3	- -
5.403 CPC	5 to 2000		up to 10^7

The Combination of a DMA for the nano particle sizing and a CPC for the particle counting is called Sequential Mobility Particle Sizer + Counter (SMPS+C). The CPC and the DMAs are operated with 0.3 litre per minute in general.

Last but not least the SMPS+C can be operated simultaneously with a aerosol spectrometer model e.g. 1.108 described above. This set up will cover a size range from 5.5nm up to 20 and is called Wide-Ragne-Aerosol-Spectrometer (WRAS). All devices can be operated simultaneously with one computer online or stand alone, mobile, due to their battery powered specification and handy dimensions. The Compact, portable WRAS setup with a “Vienna” type M-DMA, CPC and 1.108 aerosol spectrometer determines online particle concentration and size distribution in the size range of 5.5 nm to 20 µm in 59 size channels.

Application example in a thermal waste combustion energy plant

In January 2007 the Grimm Wide Range Aerosol Spectrometer was used to measure particle number concentration and particle size distribution in the exhaust air of a thermal waste combustion energy plant. The measurement took place in Bozen, Italy in cooperation with Eco-Research (Bozen, Italy), Dioxin Monitoring System (Kottingbrun, Austria) and Grimm Aerosol-Technik (Ainring, Germany).

The measurement took place at the exhaust chimney. The sampling was done isocinetically by use of a modified continuous dioxin sampling system developed and designed by Dioxin Monitoring System. The sampling system is heat able and dilutes the exhaust air with a ratio of 1:7 to avoid condensation and to reduce sampling air temperature before passing the particle counters. The temperature of the sampling system was 130°C and the total volume flow was 5 m³/h. The measurements have been done at three sampling sites. First in the background air at the chimney, second in the exhaust air of the thermal combustion energy plant and last next to the highway passing the plant. Figure 1 gives some impression of the measurement.

Figure 1: Chimney of the thermal waste combustion plant in Bozen and set up with the sampling probe and Wide Range Aerosol Spectrometer.

The results of the continuous dioxin measurements wont be discussed in this paper. The focus will be on the aerosol particle data. shown in the following diagrams.

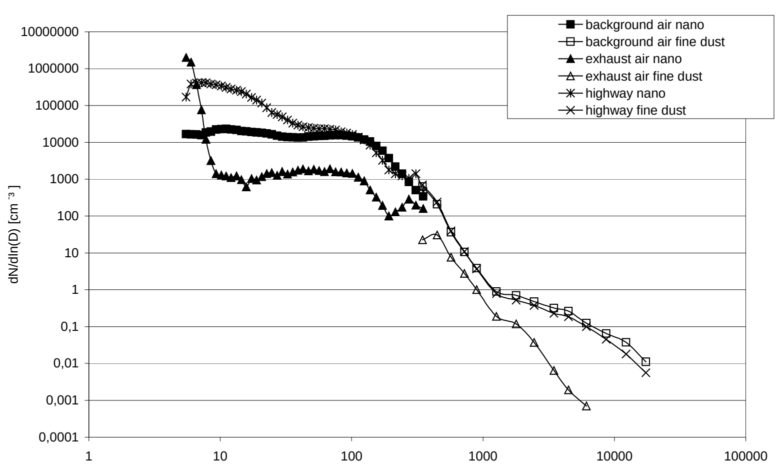

Figure 2: Particle size distribution in the size range 5.5nm to 20µm measured at the three sampling sites background air, exhaust air and near the highway.

The three locations are clearly indicated by differences in their particle size distribution and their particle number concentration. For all particles >10 nm the exhaust air shows the lowest concentrations, while the particle concentration near the highway is, with exception of the very small nano particles, highest. In the background air there is no increased very small nano particles fraction, may be due accumulation and coagulation processes.

Figure 3 and 4 show the absolute values of particle number concentration and calculated particle mass (spherical particles, density 1 g/cm³) for five particle size fractions and for the total particle size range.

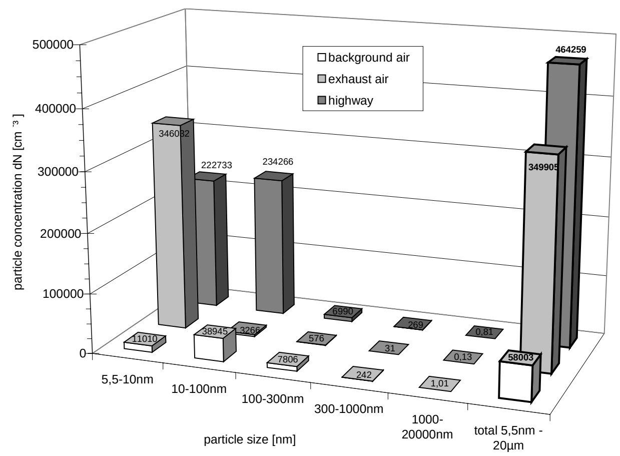

Figure 3: Mean particle number concentrations for five particle size fractions and total particle number concentration (right column) for three locations.

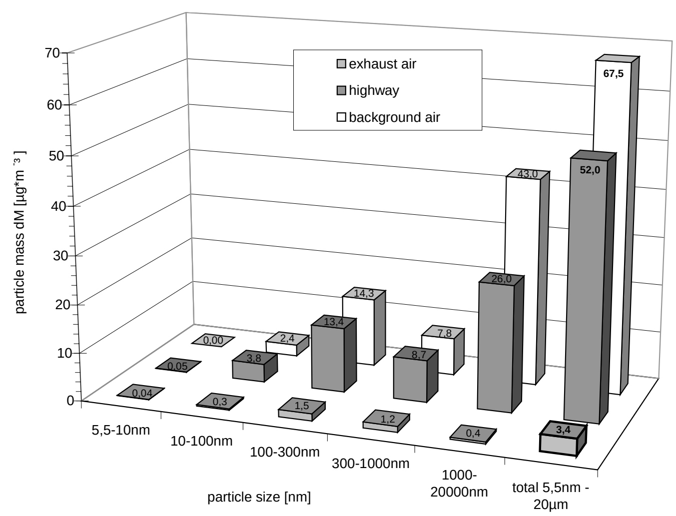

Figure 4: Mean particle mass for five particle size fractions and total particle mass concentration (right column) for three locations.

The mean particle number concentration indicates different particle sources due to different processes of particle formation. As shown small nano particles are emitted at the highway (combustion from vehicles) and in the exhaust air of the plant due to gas to particle conversion, while this fraction (5.5 nm to 10 nm) decreased in the background air. Main reason for the low nano particle concentration in the background air might be accumulation and coagulation to bigger particles and interaction with surfaces of bigger particles. The knowledge of the particle size (number and mass distribution) gives much more information than e.g. only total particle mass as received from common -samplers or other techniques. By knowing only the total mass (see right column in figure 4) a lot of particle size and number information is completely lost, or in other words, information about nano particle fraction is received from particle counting techniques only. To get precise information about the particle matter of a exhaust air, efficiency of mitigation and cleaning techniques and potential for process optimizing the whole particle size range – from nano to micro – has to be taken into account.

The Grimm Wide Range Aerosol Spectrometer offers a powerful and flexible technique for particle measurement within a very large size range (almost four orders of magnitude!) and concentration range (more than six orders of magnitude!). As shown in this work, this technique also can be integrated into existing continuous sampling techniques, easily.

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