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DETERMINING CONCENTRATION OF SOLID AEROSOLS USING LIGHT SCATTERING PRINCIPLES

The paper deals with the issue of determination the concentration of solid aerosols, provides various methods and focuses in detail to determine the concentration of solid aerosols using a device that works on the principle of light scattering. The paper includes an explanation of this principle and points out its advantages and possibilities of using in practice. The paper also presents the results of experimental measurements in two classrooms with different boards. The result of the experiment is to determine the concentration of solid aerosols, results of measurements and highlight the differences in the concentration of solid aerosols in different classrooms.

***Key words**: solid aerosols, light scattering, concentration*

1. INTRODUCTION

Solid aerosols in the working environment significantly affect the quality of the air in working environment. Aerosols have a negative impact on human health and also affect the technology. So it is necessary to monitor the concentration of solid aerosols of exposed workers and occupational exposure.

Solid aerosols in working environment cause a lot of negative – reduce visibility, spread contamination and can cause illness and low worker productivity from the inhalation of toxic substance. Many of them are also recognized as contributory factors to many chronic and acute medical conditions, including asthma, bronchitis, and lung cancer.

To determine the each factor of dust is used a lot of methods and instruments. The methods can be divided into different groups according to:

- sampling points,
- evaluation method,
- collection period,
- measurement purposes,
- physical principle.

The categorization methods of the physical principle of measuring the concentration of solid aerosols:

- gravimetric method – measured volume of air is drawn through a collection substrate such as a filter counted in a sampler, and the mass of dust collected is determined by weighing the substrate before and after sampling,
- numeric method – used to determine the number of particles analysed solid aerosols. The collected samples were chemically analysed, or spectrograph, where the presence of the necessary amount of toxic substances or fibrogenic. The numerical methods include: optical methods, methods based on the triboelectric phenomenon and methods based on the absorption of β radiation. [1, 2]

2. PRINCIPLE OF THE OPTICAL METHOD

The principle of the optical method using light scattering:

- Particles pass through a laser beam and the light scattered by them is collected over a range of angles in the forward direction.
- The angles of diffraction are, in the simplest case inversely related to the particle size.
- The particles pass through an expanded and collimated laser beam in front of a lens in whose focal plane is positioned a photosensitive detector consisting of a series of concentric rings.
- Distribution of scattered intensity is analysed by computer to yield the particle size distribution.

Scanning scattered light allows low concentrations of solid aerosols in the air. Popular device using this principle is real-time monitoring instrument.

3. INSTRUMENT USING OPTICAL METHOD

The instruments using optical method are used for real-time solid aerosol monitoring. These monitoring instrument are designed specifically to measure the levels of particulate matter such as dust, smoke, fumes, pollen and other aerosols from combustion, materials processing, manufacturing, energy generation, vehicle engine emissions, and construction are not widely available. Real-time monitoring instrument can effectively locate areas where dust controls are needed and determine how well they are working. It is developed for real-time measurement of dust concentration measured in working and also living environments. [1, 2]

The objective of this research was to characterize the ability of the real-time solid aerosols monitoring instrument to measure aerosols of varying size and composition in working environment. It is ideal survey instrument for assessment of real-time particulate concentration in $mg.m^{-3}$. It is ideal for walk-through surveys or continuous evaluation of workplace or ambient environments.

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It can quickly highlight high dust situations and allow the situation to be corrected. The great advantage is ability of real-time dust monitor to quickly and accurately measure changes to longwall dust levels after implementation of an improvement. [2]

This instrument uses a proven forward light scattering principle to make accurate and repeatable measurements of solid aerosols concentration. This principle is briefly presented in figure 1. Modulated beam of infra-red light pass into a measurement chamber. Under clean-air conditions, all light is prevented from reaching the received by a light stop. When the air is contaminated by solid aerosols, particles enter into sample volume. The beam of infra-red light is scattered within a narrow angle to receiver.

By using a narrow angle of scatter, the instrument is made less sensitive to variations in the refractive index and color of measured particulate. [3]

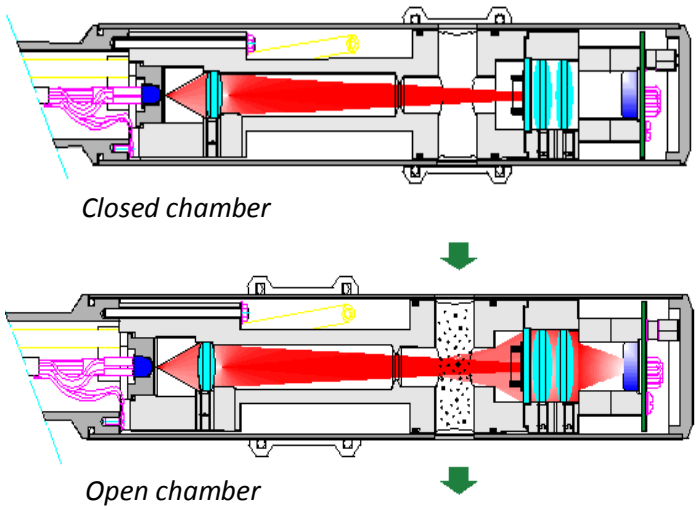


Fig. 1 Probe – light scattering principle [4]

Devices using this principle can be used for monitoring in real time or with a particle on the filter, or in combination with a cyclone, a filter cartridge and a sampling pump for the gravimetric measurement method (Fig. 2).

Fig. 2 Adapter for gravimetric method

Industry application of real-time solid aerosol monitoring instrument:

- risk assessments for dusts and aerosols,
- monitoring dust levels within the workplace,
- industrial process monitoring,
- testing respiratory equipment or air filtration efficiency,
- environmental dust assessments,
- boundary monitoring for construction and demolition,
- research activities.

Fig. 3 Real-time dust monitoring instrument in practice

4. EXPERIMENTAL MEASUREMENT

The purpose of this paper is to demonstrate the potential of real-time monitoring of chalk dust using equipment with IR technology and compare results measured in two different classes. The concentration of suspended particulate matter was measured with the optical dust monitor MicroDust Pro (Fig. 4).

Fig. 4 Real-time solid aerosol monitoring instrument – MicroDust Pro [3]

The Microdust Pro instrument uses a proven forward light scattering principle to make accurate and repeatable measurements of dust concentration. It provides the following features as standard:

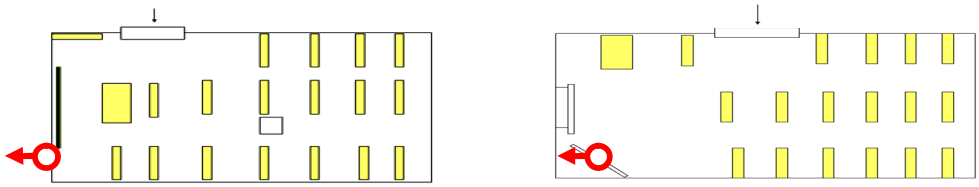
- graphical representation of concentration trends,
- internal data logging,
- a simple and clear colour user interface,
- wide measurement concentration capability to suit a vast range of dust monitoring applications.

The Microdust Pro instrument allows to download data to the Casella Insight Data Management Software and stored on PC by location, process or person and analyzed in graphic detail. This application provides a real-time display of particulate concentration levels measured by the instrument.

Microdust Pro has the highest maximum measurement range of any hand-held real-time solid aerosol monitoring instrument available today and can be zero- and span-calibrated in the field for maximum accuracy. [3]

The measurement was realized in two classes with different boards – with blackboard (C1) and magnetic white board (C2).

The instrument is situated at the distance 1 m from the board and 1,5 m above the floor. The location of samplings is presented on figure 5. The duration of measurement was 120 minutes. In both cases, the measurement was realized during standard mode (during lessons). The logger interval was set for 2 seconds.



C1 C2

Fig. 5 Sampling points

After the sampling data stored in the instrument was downloaded to PC, management and analysed. On figures 4 and 5 there are presented profile of measured concentration. Fig. 4 displayed data from class C1 and fig. 5 displayed data from class C2.

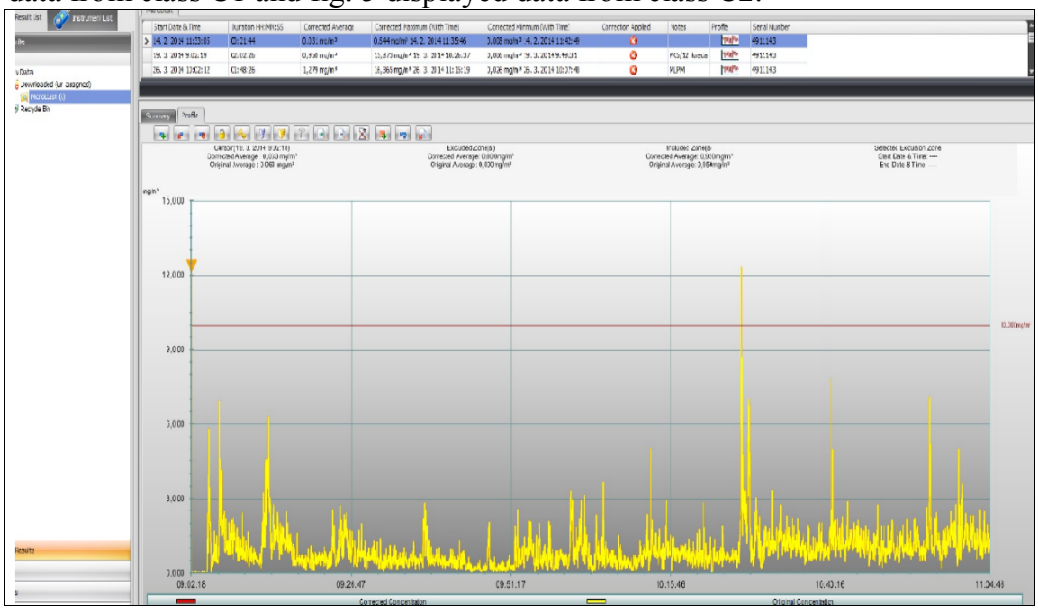


Fig. 4 Profile of measurement – class C1

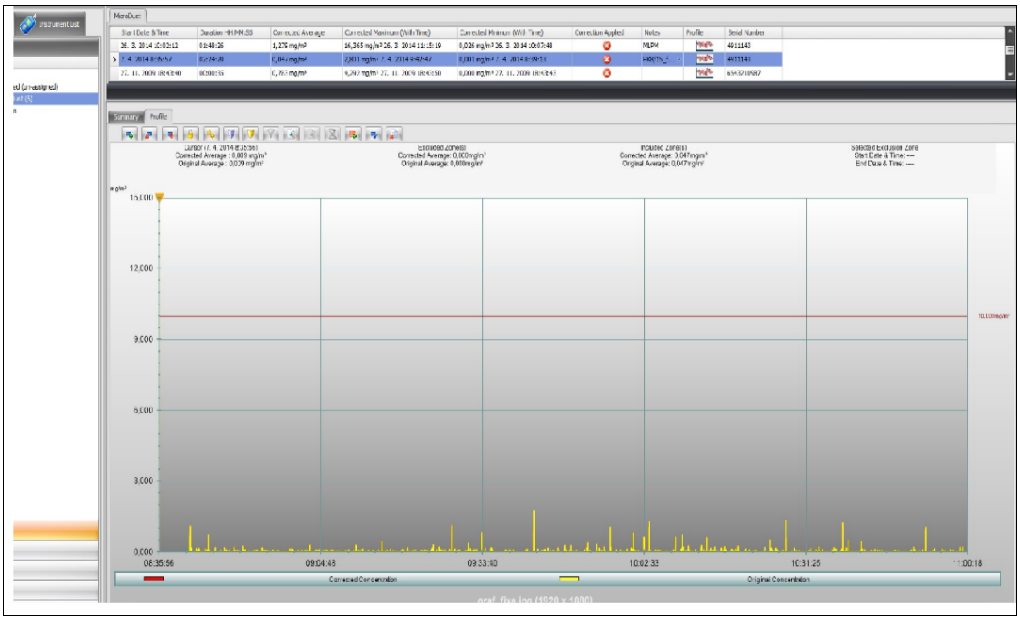


Fig. 5 Profile of measurement – class C2

The results of measurement are presented in next table (Tab. 1). There are presented average, maximum and minimum value of concentration.

Tab. 1

Results

Value of concentration [mg.m^{-3}]	Sampling point – class	
	C1	C2
Average	0,950	0,047
Maximum	15,873	2,801
Minimum	0,006	0,001

The comparing of profiles of measurement on Fig. 4 and 5 confirms that in the class C1 there is higher concentration of solid aerosols than in the class C2. Experiments also show

that during writing on blackboard or cleaning blackboard, the concentration rises. The highest concentration is achieved during cleaning blackboard. These results confirm originally supposition. From profiles on Fig. 4 we can also infer that solid aerosols produced during writing or cleaning the blackboard have high weigh and they cannot float in the air for a long time. These kind of solid aerosols quickly fall down and people, who are in the class, do not breathe in these aerosols.

5. RESULTS

Continuous registration of dust concentration showed peak values for writing with chalk, especially during cleaning blackboard. Because particulates of solid aerosols from chalk are heavy, they fall fast on the floor, and thus do not operate long-term. This is the reason why are people exposed for a very short time and there are no long-term negative effects on human health. The measurement demonstrates that magnetic white board become better alternative to classical blackboard.

The research also demonstrates that real-time monitoring using IR technology may become a viable alternative to conventional methods of monitoring of solid aerosols.

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