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VALUATION OF THE INDUSTRIAL AREAS WITH HIGH PARTICULATE CONCENTRATION USING A WIRELESS APPROACH

BY

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Abstract. The concentration of the air particles in an industrial environment can be monitored in different areas, indicating where the level of pollution is the greatest. There are four types of measurements: TSP (totally suspended particles), cyclone, PM 2.5 and PM 10 (particulate matter) that can be made with a dust monitor in real time. Because the monitoring application is tested in hazardous and crowded places, such as a brickyard quarry or a welding facility, a wireless approach is more appropriate.

Key words: environmental monitoring; wireless interface; pollution control.

1. Introduction

The need to monitor and evaluate the air pollution in the industrial environment is beneficial to implementing the right measures for protecting the medium (keeping the environmental pollution as low as possible), for improving the workers' output (increasing life expectancy and avoiding

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pulmonary diseases) or for economic reasons (preventing damage to the instruments). The limits which were imposed for the dust and respirable particles found in the atmosphere represent the starting point for valuation of the results of our measurements. The micro-dust particles with a 2.5 μm diameter (PM 2.5) are the most harmful for workers' health, but also to be considered, are the respirable particles with a 10 μm diameter (PM 10) (Ott ***et al.***, 2008). For the former, the European Parliament has established a limit of 25 $\mu g/m^3$, starting with the year 2010, and for the year 2020 this limit could be 20 $\mu g/m^3$. This paper will present in the following sections how to measure the particulate concentration and determine the 'hot spots' where the air pollution reaches the imposed limits by using a wireless interface.

2. Particulate Concentration Analysis with the Dust Monitor

The dust monitor is capable to estimate the concentration of the suspended particle matter. The variations in dust concentration are presented graphically on the instrument or on the PC in real-time (Casella Microdust, 2008). Some of the features of this instrument are particularly suited for applications such as monitoring air pollution namely

a) Measuring range from 1 $\mu g/m^3$ to 2.5 g/m^3.

b) Measurement with logger in 15,700 points.

c) The possibility to measure TSP, PM 2.5, PM 10 and cyclone concentrations.

d) Remote control operation with PC.

In order to measure the particulate concentration, the dust monitor uses a near forward light scattering technique. Infrared light of 880 nm wavelength is projected through the sensing volume where contact with particles causes the light to scatter. The amount of scatter is proportional to the mass concentration and is measured by the photo-detector. There are three different gravimetric adapters which are available with the dust monitor, and depending on the particulate concentration measurement these are

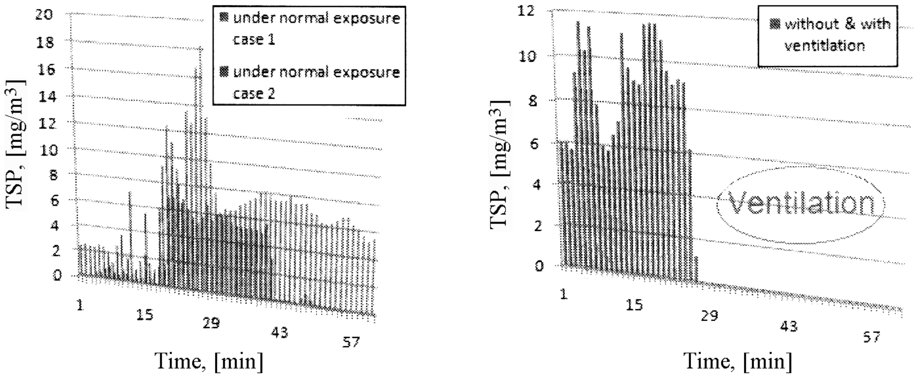
a) TSP – all the particle samples are managed in real-time and deposited on a standard filter.

b) Cyclone – only some respirable particles (with a 4 μm diameter) get through the sample and are deposited on the filter.

c) With P.U.F. (polyurethane foam) – the filters with P.U.F. can be selected for a standard size such as PM 2.5 for microdust particles with a 2.5 μm diameter, PM 10 for respirable particles with 10 μm or for respirable particles with 4 μm (such as cyclone).

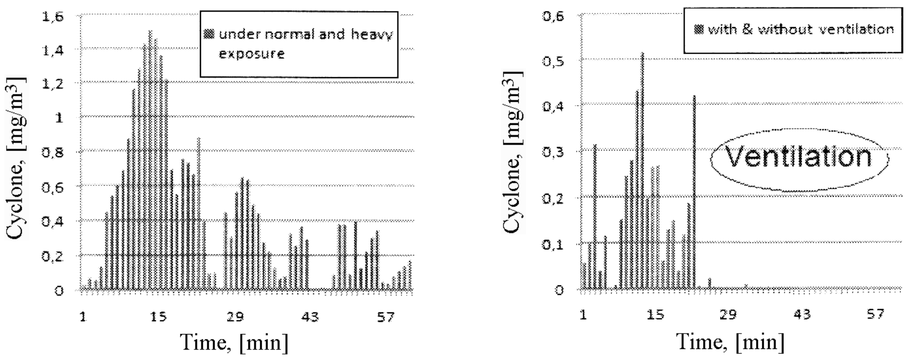
3. Measurements

The two analyses are performed for the following industrial scenarios: in a facility in which welding is made with MIG/MAG (metal inert gas/metal active gas) wires and electrode wires, and, respectively, in a brickyard quarry in different zones. For the welding scenario there are also two possibilities: to have ventilation or not. The results of our measurements in the welding facility are presented in Figs. 1,…,3. The measurement time is 1 h for each case, with one sample per minute.



a *b*

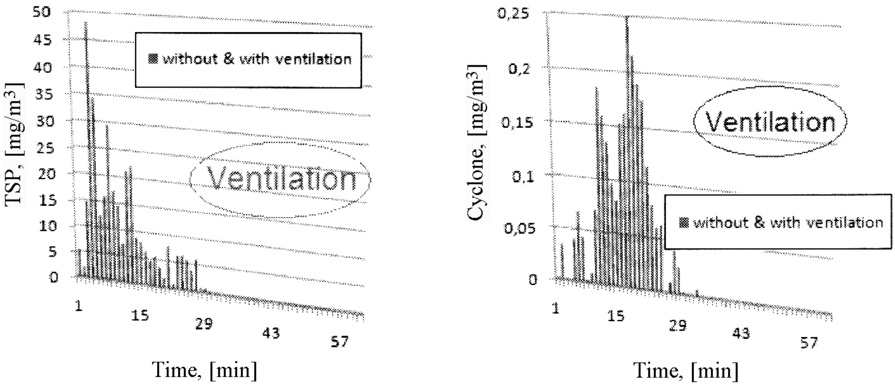
Fig. 1 – TSP analysis for welding with MIG/MAG wire under normal exposure: *a* – in two cases, no ventilation; *b* – without and with ventilation.



a *b*

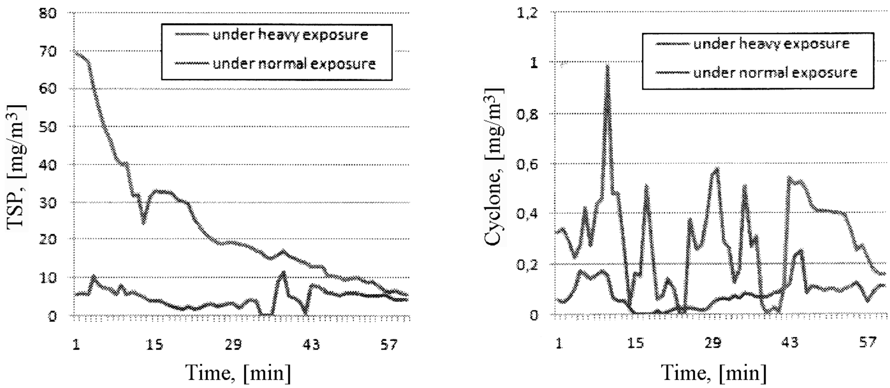
Fig. 2 – Cyclone analysis for welding with MIG/MAG wire under normal and heavy exposure: *a* – no ventilation; *b* – without and with ventilation.

In the brickyard quarry the effect of ventilation cannot be expressed since it is not present in this medium. Yet there are zones with high particulate concentration that would require monitoring, as the measurements in Fig. 4. The TSP analysis is most revealing when it comes to identify high concentration areas. These areas are usually defined for values of TSP concentration above 40 mg/m^3.



a *b*

Fig. 3 – *a* – TSP analysis; *b* – cyclone analysis, for welding with electrode wire under normal and heavy exposure, without and with ventilation.



a *b*

Fig. 4 – *a* – TSP analysis; *b* – cyclone analysis, in the brickyard quarry.

While TSP analysis determines the concentration of all the suspended particulate matter regardless of the particle size, then PM analysis uses special filters in order to select the standard size of the particle. The PM 2.5 analysis determines the concentration of micro-dust particles with 2.5 μm in diameter and the PM 10 analysis evaluates the concentration of respirable particles with 10 μm in diameter. The PM measurements are made in the brickyard quarry, where there is no ventilation (Fig. 5). The particulate matter concentration measurements have shown that the limits imposed by European standards can be exceeded in some cases. These are represented by high concentration areas which should be monitored in real time. Figs. 6 and 7 present the concentration distributions of the four types of analysis: TSP, Cyclone, PM 2.5 and PM 10. This distribution helps to determine the most polluted areas, which is especially practical inside a brickyard quarry where ventilation is not present.

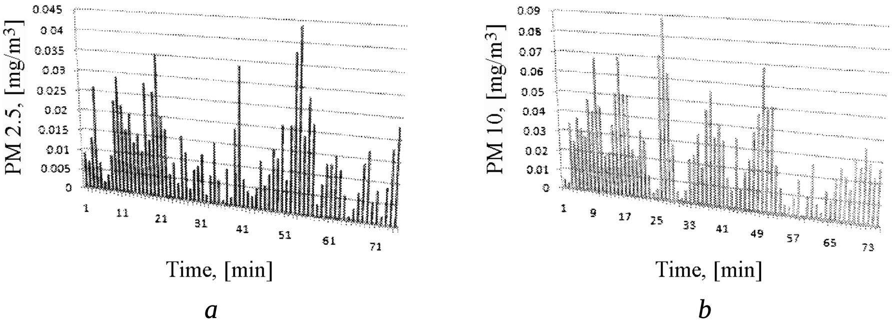


Fig. 5 – *a* – PM 2.5 analysis; *b* – PM 10 analysis, in the brickyard quarry.

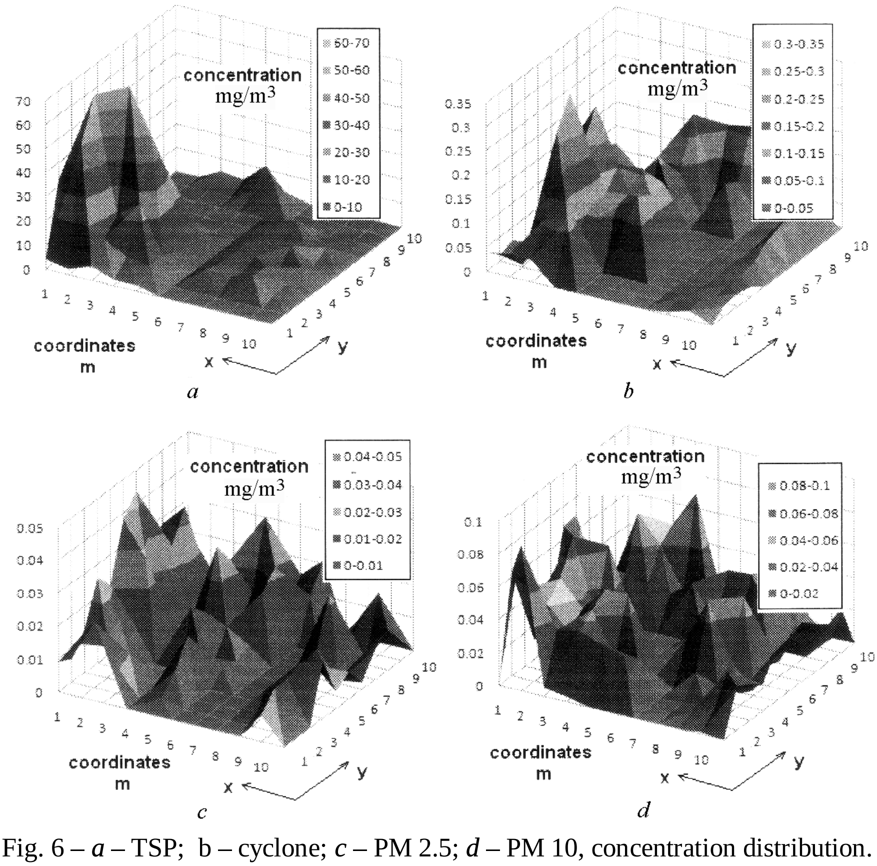
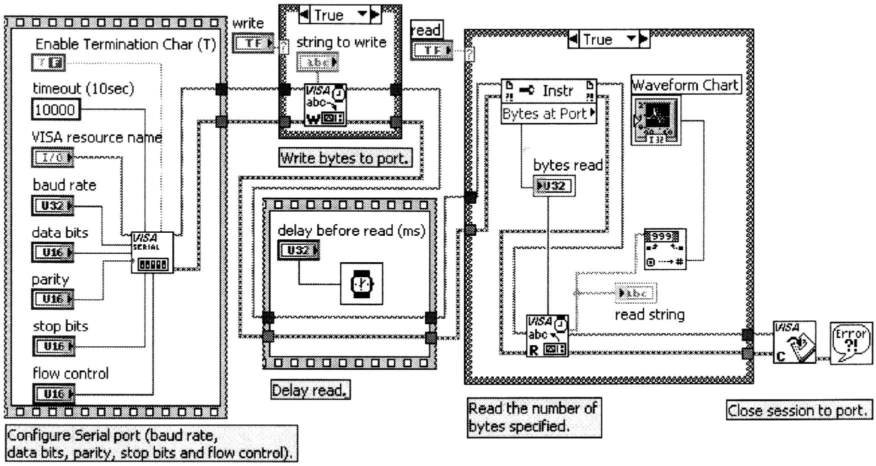


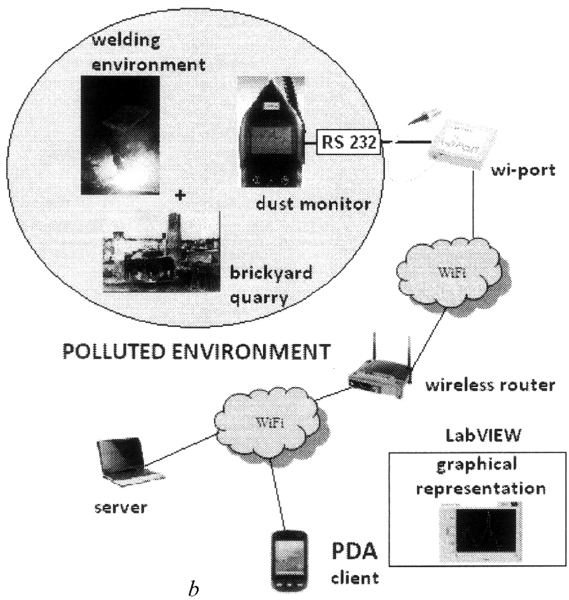
Fig. 6 – *a* – TSP; b – cyclone; *c* – PM 2.5; *d* – PM 10, concentration distribution.

4. The Wireless Interface

The measurement data is sent in real time from the dust monitor to the PC through the serial cable. Yet, for remote operation and because of safety issues inside polluted environments, a wireless interface would be considered more appropriate. The WI-PORT (WiPort Embedded…, 2009) device permits



a



b

Fig. 7 – ***a*** – The LabVIEW program for serial acquisition (Block Diagram);
b – wireless interface for monitoring the particulate concentration of polluted areas.

data acquisition on its serial port and can send the data to any device that has a

Wi-Fi receiver (IEEE 802.11). The program used with the wireless interface for data acquisition and control is based on LabVIEW software. The LabVIEW program provides a graphical representation of the bytes sent through the serial port (Fig. 7 *a*).

WI-PORT is connected to the Wi-Fi network (Shorey *et al.*, 2006), and from there its data can be accessed by any device with Wi-Fi antenna (Fig. 7 *b*). The data is distributed throughout the network by using shared variables in LabVIEW (National Instruments…). The wireless interface architecture is based on an *ad-hoc* network with Wi-Fi.

The PDA device can be seen as the client side of the network, at which, any user can visualize the measurements in real time by running the LabVIEW program. The measured data can be stored on the server.

5. Conclusions

The areas with high concentration in industrial environments are identified by performing particulate matter analysis with a dust monitor. The measurements reveal the areas that exceed the limits imposed by the European Parliament, especially PM 2.5, which can have the most harmful effects on health. A wireless approach is useful in crowded places where remote operation is required and also for safety reasons due to air pollution. The solution we propose for monitoring and controlling the acquisition of measurement data is based on LabVIEW software and on a Wi-Fi *ad-hoc* network.

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EVALUAREA ZONELOR INDUSTRIALE CU CONCENTRAŢII MARI DE PARTICULE FOLOSIND O ABORDARE BAZATĂ PE COMUNICAŢII FĂRĂ FIR

(Rezumat)

Concentraţia de particule de aer într-un mediu industrial poate fi monitorizată în diferite zone, cu indicarea locului în care nivelul de poluare este cel mai mare. Există patru tipuri de măsurători care pot fi realizate cu un monitor de praf în timp real: TSP (particule suspendate în totalitate), ciclon, PM 2.5 şi PM 10 (pulberi în suspensie). Deoarece aplicaţia de monitorizare este testată în locuri periculoase şi aglomerate, cum ar fi o carieră a unei fabrici de cărămidă sau o hală de sudare, o abordare bazată pe comunicaţia fără fir este mai adecvată.