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Gasoline exhaust filtration as a valid method of obtaining particulate matter for further analysis

Introduction

Since 1950s emission from the fossil fuelled cars have been considered as a harmful. The car exhaust gasses are part of the low emission therefore they are especially dangerous for human health and environment. In the past many methods were used to measure level of toxicity and harmfulness of exhaust components.

In the last year in Europe a new measuring method - Worldwide light duty harmonized test procedure - was considered as a standard. The WLTP that is part of the Euro 6 emission standard allows to achieve the true values of fuel consumption and emissions.

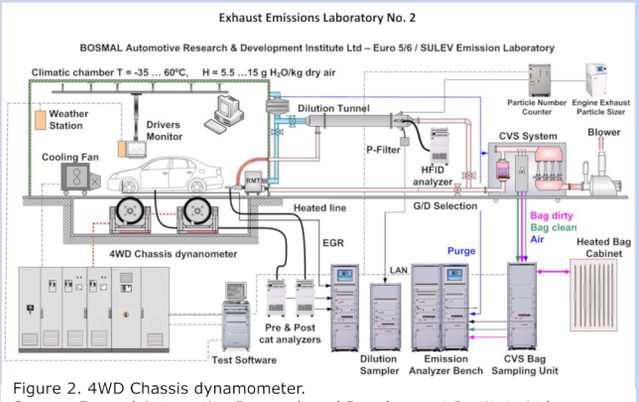

Figure 2. 4WD Chassis dynamometer.
Source: Bosmal Automotive Research and Development Institute Ltd.

Testing procedure

Vehicle acceleration, deceleration, speed and gear shift are set by the test driver according to the WLTP. The figure 1 shows the scenario for Class 3 vehicle, that have power-to-mass ratio above 34 W/kg.
The test is conducted on the chassis dynamometer located in the air conditioned chamber.

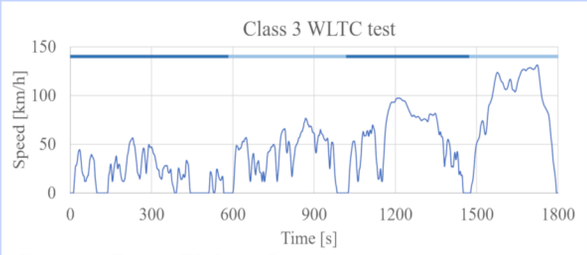

Figure 1. The WLTP Class 3 speed diagram.

During the test, part of the exhaust volume is redirected through the 47 mm filter, where the particulate matter is collected. After the procedure, filter is weighted to calculate the PM mass.
The further physical and chemical analysis can be conducted using such instruments techniques as a gas chromatography with mass spectrometry (GC-MS), an ion chromatography (IC), a scanning electron microscopy (SEM, TEM), an energy dispersive X-Ray spectrometry (EDS) or an X-Ray photoelectron spectroscopy (XPS).

SEM analysis

The figures 3-4 show filter before and after WLTC Class 3 procedure. After the test SEM allows to enumerate the concentration of the particles and measure the dimensions of the single particle collected on the surface. The tandem of SEM and EDS allows to determine the elemental composition of a given part of PM surface.

GC-MS analysis

The polycyclic aromatic hydrocarbons, their nitric and oxygen derivatives, hopanes, steranes and phosphoroorganic compounds can be quantitatively and qualitatively identified. The study of these components is justified by their significant impact on health even at low concentrations.

Ion Chromatography

IC allows to examine ion composition of the particulates. Both cations such Na^+, K^+, Li^+, NH_4^+, Ca^{2+}, Mg^{2+} and anions like F^-, Cl^-, Br^-, NO_2^-, NO_3^-, PO_4^{3-}, SO_3^{2-}, can be measured. Ions can originate from the gasoline or engine oil additives, that are improving their properties.

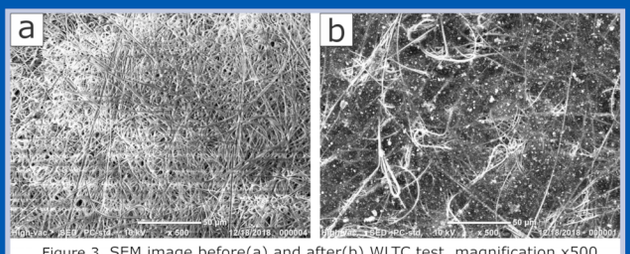

Figure 3. SEM image before(a) and after(b) WLTC test, magnification x500

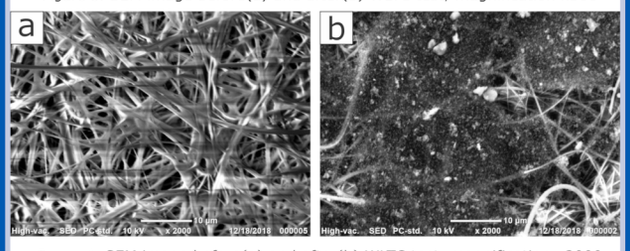

Figure 4. SEM image before(a) and after(b) WLTC test, magnification x2000

Other sources

Testing environment allows to measure only primary particulates, originated form the drivetrain.
The secondary particulates are formed due to temperature gradient or in the reactions with other air pollutants. Additionally the particles can be emitted from the brakes and tires.

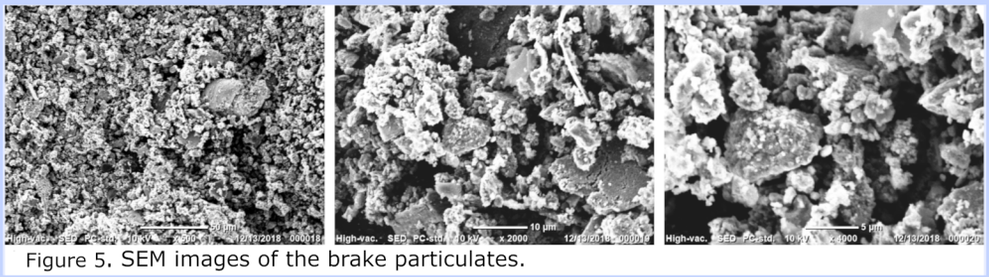

Figure 5. SEM images of the brake particulates.

The figure 5 shows particles collected from braking system test bench. The particulate number and size distribution can be measured with Engine Exhaust Particle Sizer Spectrometer. The physiochemical properties can be examined with the same methods as primary particles

Conclusions:

The particulate matter should be further analysed because its negative impact on health and environment. Current analytical methods allow to conduct deep study of the chemical and physical nature of the particulates originated from fuel and engine oil combustion, components wear, brakes and tire abrasion. The specific elements, ions and compounds can be connected to the source of emission

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