ISSN: 1231-4005
e-ISSN: 2354-0133
ICID: 1133902
DOI: 10.5604/12314005.1133902

A NEW ECOLOGICAL RESEARCH – REAL DRIVING EMISSIONS

Jacek Pielecha, Agnieszka Merkisz-Guranowska

Poznan University of Technology
Faculty of Machines and Transportation
Piotrowo, 60-965 Poznan, Poland
tel.:+48 61 6652207, +48 61 6475958, fax: +48 61 6652204
e-mail: jacek.pielecha@put.poznan.pl, agnieszka.merkisz-guranowska@put.poznan.pl

Ilona Jacyna-Gołda

Warsaw University of Technology
Faculty of Production Engineering
Institute of Organization of Production Systems
Narbutta Street 85, 02-524 Warsaw, Poland
tel.:+48 22 2348126, fax: +48 22 8499390
e-mail: jacyna.golda@gmail.com

Abstract

In the assumptions, regarding to the transport policy both at the level of country and Europe there is the concept of sustainable development of transport. Warsaw University of Technology in cooperation with Poznan University of Technology performs research work concerning the shaping of environmentally friendly transport system – Project EMITRANSYS. In this project, one of the conditions is to reduce exhaust emissions by means of transport. The paper presents the reasons for the testing of the exhaust emissions under Real Driving Emissions testing (RDE). Research potential of Institute of Combustion Engines and Transport at Poznan University of Technology in the area of road testing of passenger and heavy-duty vehicles has been presented in the paper. Example test results have been shown in the aspect of the emission-related classification of vehicles. The major challenge of worldwide emission standards, engine operating parameters in various emissions tests, the test potential under real operating conditions, the view of the analyser for on-road emission testing of vehicles, the test results for road emission of CO, HC and NOx, detailed characteristics of the averaged particle number for the entire test run (vehicles with different mileage and different emission class) for: Euro 4 class and 75,000 km; Euro 4 class and 500,000 km; Euro 5 class and 75,000 km; Euro 5 class and 500,000 km are presented in the paper.

Keywords: *exhaust emissions, vehicle testing, Real Driving Emissions*

1. Introduction

Currently a trend has been seen of global treatment of the environmental perils from the automotive industry. The regulations permitting the vehicle to drive on roads (homologations and production conformity), periodical inspections of the vehicle technical condition and other legal acts directly or indirectly related to the production, use and disposal of used up civilization products treat the environmental issues in a complex way. In the previous years in individual countries, there were different inspection and testing systems related to the exhaust emissions yet for some time now, there has been a far-reaching unification going on [1–3].

The growing number of vehicles in the world and the resultant natural environment pollution leads to a growth in the emission related requirements (Fig. 1). Current level of technology advancement in all the fields of industry including transport results in a growth of the requirements for the emission measurement devices. In order for these requirements to be fulfilled to comply with the ever-changing regulations, a concentration of industry became necessary in this matter.

The exhaust emission tests are a sophisticated process. Modern analysers of the emissions require special laboratory conditions and the homologation procedures comprise tests on chassis and engine dynamometers that do not entirely reflect the emissions under real operating conditions. The latest results of on-road tests show that in relation to some exhaust components the emission is higher by several hundred percent for both the gaseous compounds and [1, 4-6] particulate matter [7, 8]. Hence, we can see a trend attempting at a formalization and enforcement of the on-road emission testing.

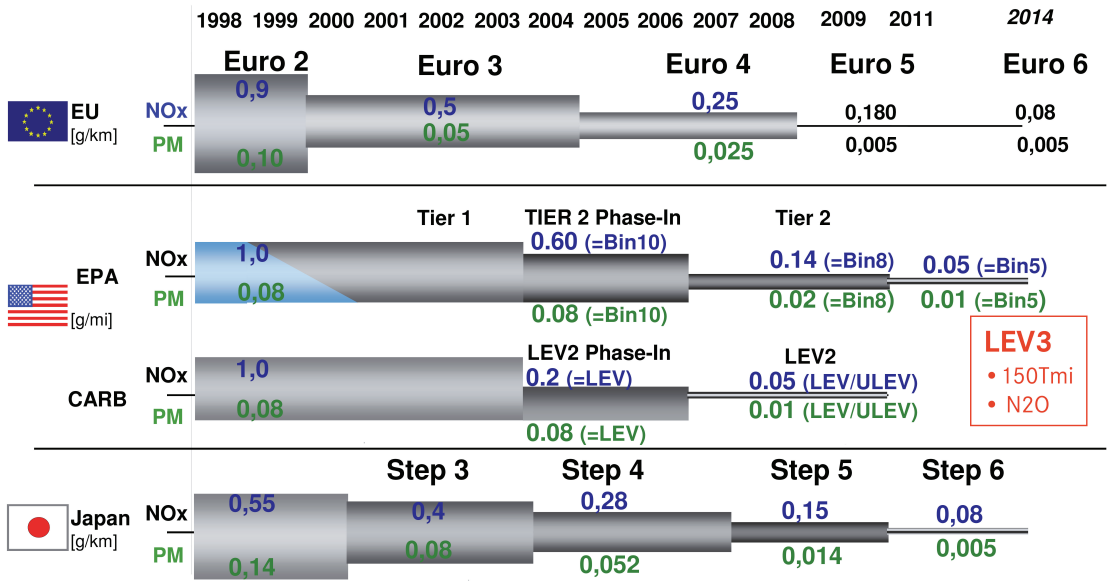

Fig. 1. The major challenge is to fulfil the worldwide emission standards [9]

2. Real Driving Emissions

Manufacturers of combustion engines are obliged to the design drive units with best possible ecological characteristics and with supreme performance parameters. In recent years, the popularity of measuring parameters of combustion engines in real operating conditions has significantly increased. The latest results of tests carried out in real traffic conditions show that some components of exhaust emissions are emitted in greater amounts compared with the tests carried out on stationary engine test benches. The lack of legal provisions regarding the testing of emissions in real traffic conditions resulted in the need to determine common areas of operating of the engines in order to enable the comparison between the engines [1]. The concept of exhaust gas toxicity tests performed in real traffic conditions for passenger vehicles should be based on the following premises: determination of a consistent area of operation of the engine for all passenger vehicles in a way to the greatest extent corresponding with the most common traffic conditions, determination of the parameters measured during the road tests and the obtained emission indicators [2, 3]. The article presents the results of the measurements concerning determination of working conditions for the engines used to drive the cars. The tests of working conditions were carried out for a group of vehicles driving along the predefined sections of roads in urban traffic and out-of-town traffic. The result of the study was the assessment of the working conditions of passenger vehicles considering determination of road emissions of pollutants.

Measurements of emissions in passenger cars are conducted during the type-approval tests on the chassis dynamometer, during the road tests in real traffic conditions and on vehicle inspection stations (there the concentration of compounds is measured and not the emission). The type-approval measurements are performed on the chassis dynamometer according to precisely

determined procedures and are used only for new passenger cars. The aim of the NEDC (New European Driving Cycle), WLTP (Worldwide harmonized Light vehicles Test Procedures) and the American US 06 (Federal Test Procedure) type-approval tests for a fixed speed profile are to control whether a vehicle meets ecological requirements (Fig. 2) [4]. Road tests of passenger vehicles concerning exhaust emissions are not legally regulated as opposed to heavy goods vehicles, for which the research test NTE (Not to Exceed) has been designed – the test checking whether the vehicle does not exceed the limit values [5].

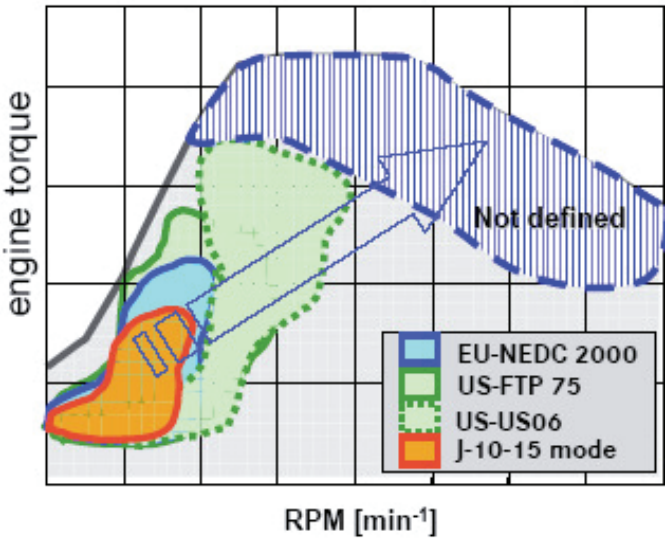

Fig. 2. Engine operating parameters in various emissions tests [9]

The recent developments in the European legislation reflect the interest of the regulatory authorities to shift from the chassis/engine dynamometer testing towards a real-time on-board regulation of vehicular emissions. This transition has been successfully implemented for gaseous pollutants and particulate matter. The more ambitious target of on-board particle number measurements is currently under evaluation. While a number of approaches can be considered, a successful implementation needs to effectively address a number of considerations [10]:

- it needs to incorporate a very efficient conditioning system to address the potentially elevated concentrations of volatile particles under more aggressive real world driving,
- it needs to incorporate a particle detector that would be robust enough to withstand the much harsher operating conditions during field testing,
- it should be simple in operation and allow for easy on-site checks of all critical components.

2. Portable Emissions Measurement System

The most desirable are on-road emission tests as this is the only way to measure the actual emission level. The biggest disadvantage of this method is the price of the equipment and its adaptation to individual vehicles. Following the latest trends, Institute of Combustion Engines and Transport equipped its Combustion Engines laboratories with modern research tools such as the system of Semtech DS, Ecostar and M.O.V.E exhaust emission analysers with measuring probes (exhaust flow meters) manufactured by Sensors Inc. and AVL. The system of analysers measures the exhaust emissions from combustion engines fitted in all types of machines and vehicles under the conditions of their real operation (Fig. 3 and 4).

Since 2008 a series of passenger vehicle emission tests (Fig. 5) was initiated under urban and extra urban driving conditions. A portable exhaust emission analyser was fitted inside the vehicle and the measuring probe outside the vehicle. The tests consisted in a continuous measurement of

the emissions while the vehicle was in motion on a preset road portion.

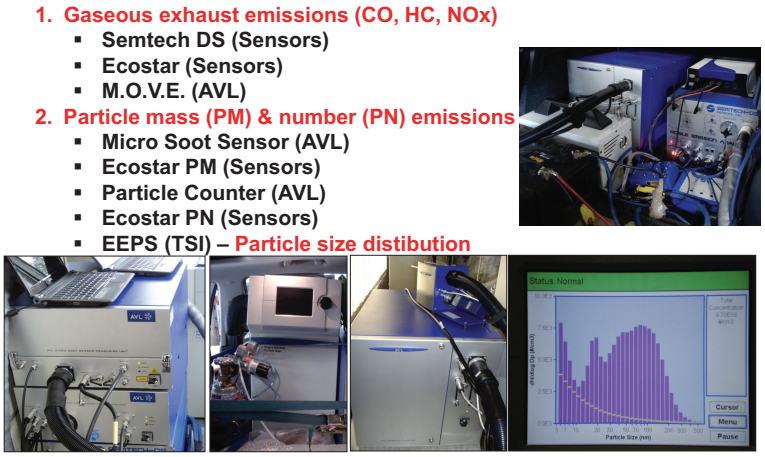

Fig. 3. The test potential under real operating conditions (analyser: Semtech DS)

a) b)

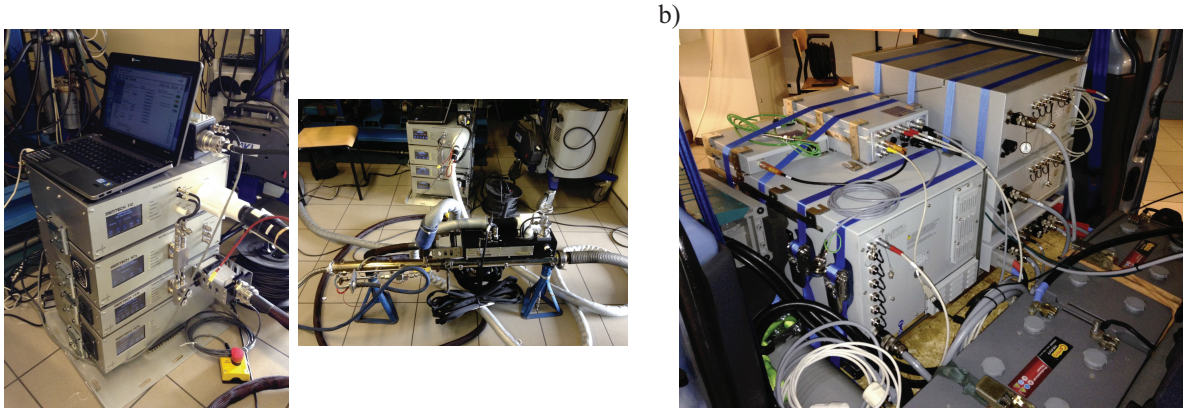

Fig. 4. The view of the analyser for on-road emission testing of vehicles: a) Ecostar by Sensors, b) M.O.V.E by AVL

The purchase of the SEMTECH DS analyser turned out to be a very good decision. As soon as after several months of its use Solaris Bus & Coach S.A. showed their interest in this kind of testing in relation to their buses: H18 (18 meter hybrid vehicle) and U18 with a conventional power train. In the second half of the year, the devices were fitted in the buses and the tests were carried out. The obtained results allowed an evaluation of the exhaust emission level of the tested buses in the traffic in the city of Poznan. The collaboration between Institute of Combustion Engines and Transport at Poznan University of Technology with Solaris Bus & Coach S.A as well as other domestic enterprises resulted in further investigations into heavy-duty trucks, non-road machinery and special vehicles (Fig. 5).

Fig. 5. RDE in Poznan University of Technology

The performed tests and the obtained results (Fig. 6) have shown a wide potential to use the purchased equipment and indicated a need to perfect the measurement of particulate matter. As

a result, the Combustion Engines Laboratory purchased a state-of-the-art particulate matter analyser performing the measurement under real operating conditions. The following were purchased: particulate matter mass analyser– PPMD by Sensors Inc., AVL Particle Counter and Engine Exhaust Particle Sizer – mass spectrometer for the measurement of the size distribution. This means that the scientists in our laboratory can determine the PM size, their number in a given size range after a proper PM conditioning in the dilution tunnel. This equipment can be used not only in laboratory but also in dynamic conditions, e.g. during engine start, transient conditions between two processes (Fig. 7).

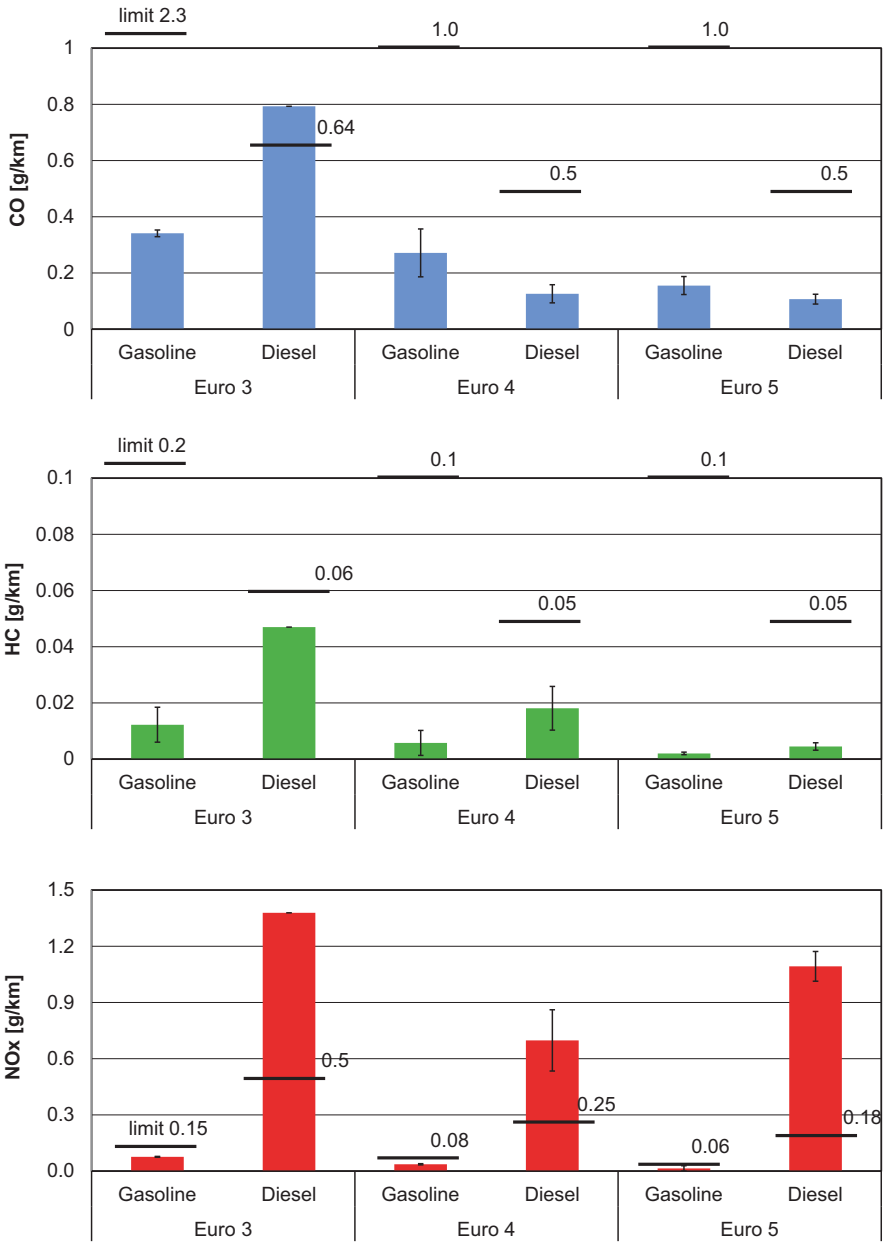

Fig. 6. The test results: road emission of CO, HC and NOx

The emission standards for combustion engines from 2009 require determining of the particle number emitted by vehicles; hence, the investment was in line with the world trends in automotive research and testing. The fact that we have the measuring devices for the particle size distribution allows us to combine the devices into a more complex system used not only in laboratory (dynamometers) but also under real operating conditions (Fig. 7). This unique system on a worldwide scale is characterized by the fact that it obtains the emission test results (all exhaust

components) immediately, which allows quick conclusions from the investigations. The purchase of the equipment for our laboratory complies with the European Union directive related to the reduction of the exhaust emissions and the evaluation of the research on combustion processes.

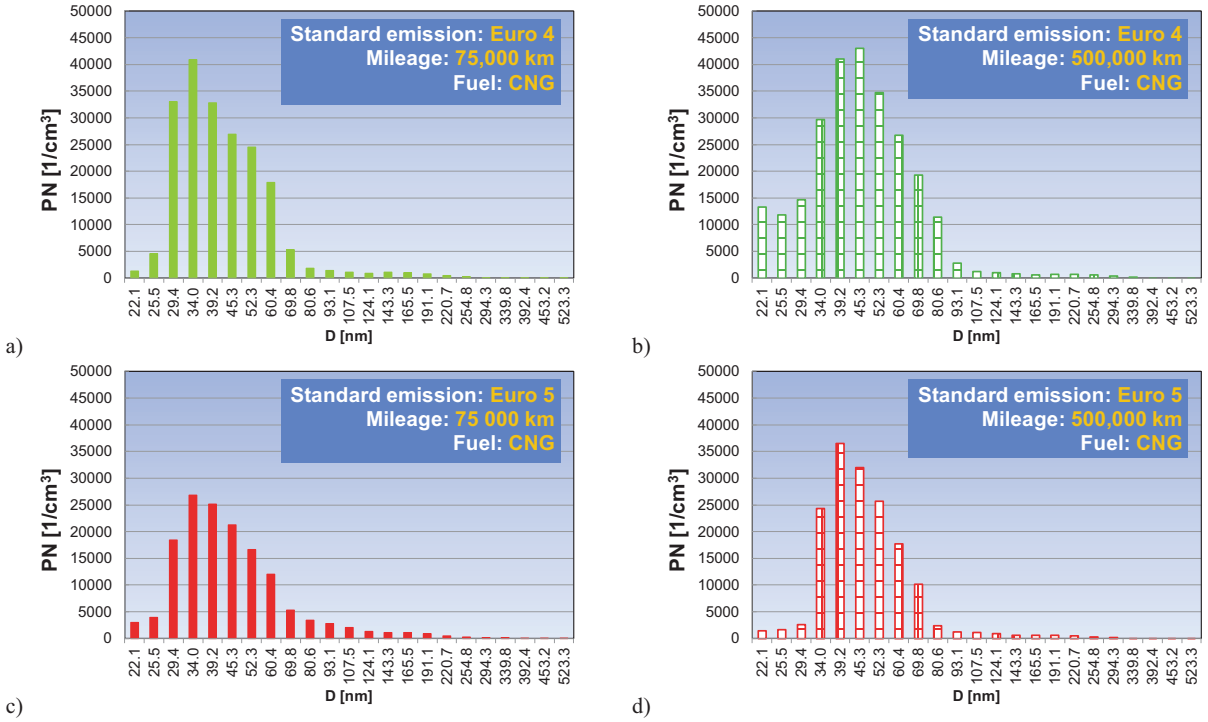

Fig. 7. Detailed characteristics of the averaged particle number for the entire test run (vehicles with different mileage and different emission class) for: a) Euro 4 class and 75,000 km, b) Euro 4 class and 500,000 km, c) Euro 5 class and 75,000 km, d) Euro 5 class and 500,000 km [11]

Conclusions

Legislators are currently working on a new test method, which should limit the emissions in real traffic (Real Driving Emissions) so as to sustainably reduce gaseous emissions on the roads. In comparison with the currently valid test cycle (NEDC) this represents a significant extension of the engine operation range because on the road nearly every operating point in the engine map can be driven, even when in normal driving practice these points are never used. In this way, it can be ensured that the emissions remain low in all practical driving situations. Evaluation tools from road measurements, which support the recognition of normal driving, are available; these are however in need of further fine-tuning.

The analysis of the world trends in environment protection shows that, in order to environment pollution effectively reduce, a measurement of exhaust emissions in real road operating conditions is a necessary step to take. The institute owns a system of portable analysers that enables the measurement of vehicle emission levels not only in stationary but also in dynamic conditions e.g. during engine start, transient conditions between two processes (diesel particulate filter regeneration). The system of analysers is a set enabling a complex on-board measurement of exhaust emissions in real time under real road operating conditions of vehicles fuelled with different fuels (gasoline, diesel oil, LPG, CNG, E85 etc.). A complement to the existing system is an opacimeter and a particle-measuring unit having the capacity to measure the particle mass and size (particle counter and mass spectrometer).

Acknowledgement

The research was funded by the National Centre for Research and Development (Narodowe Centrum Badań i Rozwoju) – research project within the Applied Research Programme (contract

No. PBS1/A6/2/2012).

References

[1] Johnson, T. V., *Review of Diesel Emissions and Control*, SAE Technical Paper Series 2010-01-0301.
[2] Ortenzi, F., Costagliola, M. A., *A New Method to Calculate Instantaneous Vehicle Emissions using OBD Data*, SAE Technical Paper Series 2010-01-1289.
[3] Seger, J. P., *Vehicle Integration for US EPA 2010 Emissions and Lowest Cost of Ownership*, SAE Technical Paper Series 2010-01-1956.
[4] AVL M.O.V.E iS, *A new solutions for the upcoming EU6c – Real Driving Emissions (RDE) legislation*, AVL List GmbH, Graz 2014.
[5] Merkisz, J., Pielecha, J., Radzimirski, S., *New Trends in Emission Control in the European Union*, Springer Tracts on Transportation and Traffic, Vol. 1, 2014.
[6] Merkisz, J., Markowski, J., Pielecha, J., *Selected issues in exhaust emissions from aviation engines*. Nova Science Publishers, p. 195, New York 2014.
[7] Steininger, N., *Automotive particulate emissions in European legislation: state of the art and developments to come*, 13th ETH Conference on Combustion Generated Particles, Zurich 2009.
[8] Wei, Q., Rooney, R., *The On-Board PM Mass Calibration for the Real-Time PM Mass Measurement*, SAE Technical Paper Series 2010-01-1283.
[9] Krutzsch, B., Weibel, M., Steiner, R., Schmeißer, V., *System Simulation of Modern Powertrain Concepts – From an Industrial Perspective*, Cross-Cut Lean Exhaust Emissions Reduction Simulations, Crosscut Workshop on Lean Emissions Reduction Simulation, University of Michigan, Dearborn 2011.
[10] Mamakos, A., Bergmann, A., Dardiotis, C., Florian, D., Sabbagh-Kupelwieser, N., Schiefer, E., Schindler, W., Vescoli, V., Winkler G., *Measurement of Automotive Particle Emissions within the European Legislative Framework: Status Quo and Future Trends*, AVL List GmbH, Graz, Austria.
[11] Merkisz, J., Pielecha, J., Łabędź, K., *On-road test exhaust emissions vehicle powered by compressed natural gas*, FISITA, World Automotive Congress, Paper no. F2014-CET-122, Maastricht 2014.