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## ANALYSIS OF THE PICKUP EXHAUST EMISSIONS IN REAL DRIVING CONDITIONS

The article analyzes the exhaust gases from the vehicle pickup during drive tests. The research was carried out on a vehicle of this type because of the growing vehicle sales of this type of chassis in both domestic and European level. The study was conducted in Poznan, two drives of the same track were performed - economic and dynamic. To test the exhaust emission was used PEMS apparatus (Portable Emissions Measurement System) mounted on the vehicle Nissan Navara. The collected results were presented in the form of graphs of emission plotted on the track map. They were also compared to the EU norms and administered by the manufacturer fuel consumption. Based on these results conclusions were prepared.

Keywords: exhaust emission, PEMS, RDE

### 1. INTRODUCTION

The main factor determining the trends in the development of vehicle powertrain emission standards are harmful compounds in exhaust emissions. In addition, the European Union adopted Regulation No 333/2014 by which vehicle manufacturers are expected to reduce the average CO<sub>2</sub> emissions across the vehicle fleet to the level of 95 g/km by 2020, which corresponds to fuel consumption of approx. 3.9 dm<sup>3</sup>/100 km [Delphi, 2016] in the NEDC tests (New European Driving Cycle).

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Currently the market of new vehicles is seeing an increase in the sales of SUVs and pick-up trucks [Merkisz, Pielecha 2006]. These types of vehicles are characterized by an increased size, the dimensions of the cabin, etc. They are increasingly used by the inhabitants of urban agglomerations. That's because modern diesel engines, which are prevalent in the sales offers, are characterized by the manufacturers as having low fuel consumption [Bajerlein, Rymaniak 2014]. The paper presents the results of emission and fuel consumption tests of a pick-up vehicle driving in the city center in either a cost-effective or aggressive way.

## 2. RESEARCH OBJECT

The vehicle used in this study was a II generation Nissan Navara. This is one of the most popular SUVs in Poland and Europe, characterized by considerable length of 5.30 m. The tested vehicle had a double cab allowing for the transport of up to four people transport. The vehicle's diesel engine was characterized by a stroke volume of 2.5 dm<sup>3</sup> and power of 125 kW. The car's standard product equipment was a particulate filter so it meets the Euro 5 emission standard. The vehicle is shown in Fig. 1.



Fig. 1. The vehicle used in testing with PEMS equipment

The main technical parameters of the diesel engine used in the tested vehicle have been presented in Table 1.

Table. 1. Technical parameters of the tested vehicle's engine [Nissan, 2015]

Engine type	Diesel
Number and arrangement of cylinders, number of valves	4 cylinders, in-line, 4 valves per cylinder
Displacement	2,488 dm <sup>3</sup>
Bore/stroke	89 mm / 100 mm
Maximum power	140 kW/4000 rpm
Maximum torque	450 Nm/2000 rpm
Compression ratio	15:1
Fuel injection	Common Rail
Type of charger	VGT Turbocharger
Emission reduction and aftertreatment systems	EGR, DOC, DPF

### 3. MEASURING EQUIPMENT AND RESEARCH METHODOLOGY

The equipment used in tests was a SEMTECH DS model produced by Sensors Inc. This is a system of analyzers belonging to the group of PEMS (Portable Emissions Measurement System) devices, used to measure the harmful gas components contained in the exhaust gas. Its appearance and operation is illustrated in Fig. 2.

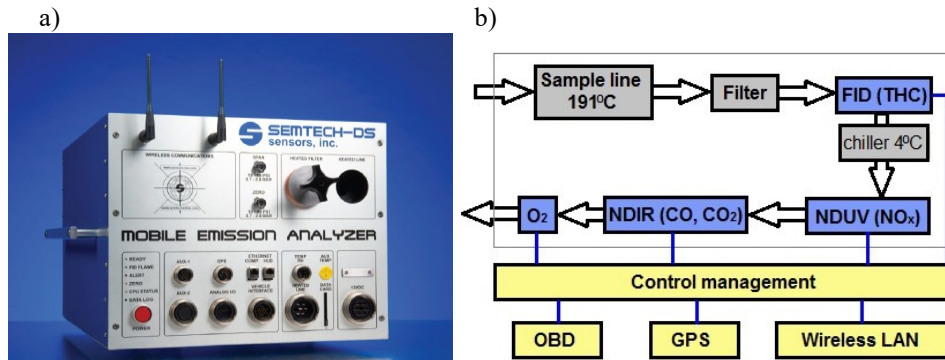


Fig. 2. a) Picture of the SEMTECH DS mobile device for exhaust emissions testing;  
b) Schematic of operation [Sensors, 2015]

A sample of exhaust gas from the internal combustion engine is collected by the exhaust mass flow rate probe. The test gas volume is transported via a special heated tube, which maintains the temperature of 191°C to prevent condensation of the hydrocarbons before the measurement of their concentration is made

[Merkisz, Pielecha, Radzimirski 2014]. Then, depending on the tested gas sample, it is passed through a filter to remove particulate matter. Exhaust gases prepared in this way are subjected to careful measurements in their respective analyzers. First the hydrocarbon content is examined in the FID analyzer (Flame Ionization Detector). In the next stage, the sample is cooled to 4°C and goes to the NDUV analyzer (Non-dispersive Detector Ultra Violet), which is responsible for the concentration measurement of nitrogen oxide and dioxide. The next step is to measure the concentration of carbon monoxide and carbon dioxide by the NDIR analyzer (Non-Dispersive Infrared Detector). In the last step, the oxygen content is measured using the electrochemical sensor. The device can store data of the engine speed and load taken from the vehicle's OBD system. In addition, the position and the vehicle speed is retained based on the GPS location system.



Fig. 3. The route chosen for the measurements [done using GPSVisualizer.com]

#### 4. ANALYSIS AND RESULTS

During the studies the emission of harmful compounds in the exhaust gas, i.e.: nitrogen oxides, carbon monoxide and carbon dioxide have been measured. FID analyzer for measuring the concentration of hydrocarbons remained inactive because, for safety reasons, the tank with hydrogen gas was not mounted on the vehicle. Basic driving parameters in both drives are summarized in Table 2, while Fig. 4 through 9 show the emissions of various exhaust components on the test route.

Average results of tests with comparison to norms were shown in Table 3.

Table 2. Basic parameters recorded for the performed drive tests

Data	Dynamic drive	Economic drive
Travel time [s]	1131	1274
Average speed [km/h]	37,2	33,1
Average acceleration [ $m/s^2$ ]	0,452	0,384
Average deceleration [ $m/s^2$ ]	0,562	0,446

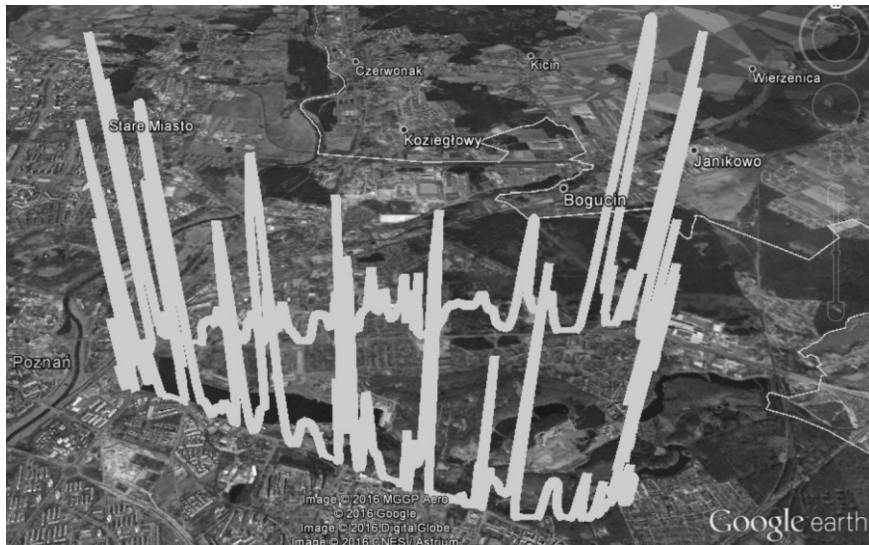
Fig. 4. Results of the CO<sub>2</sub> emissions during dynamic drive

Fig. 5. Results of the CO emissions during dynamic drive



Fig. 6. Results of the  $\text{NO}_x$  emissions during dynamic drive

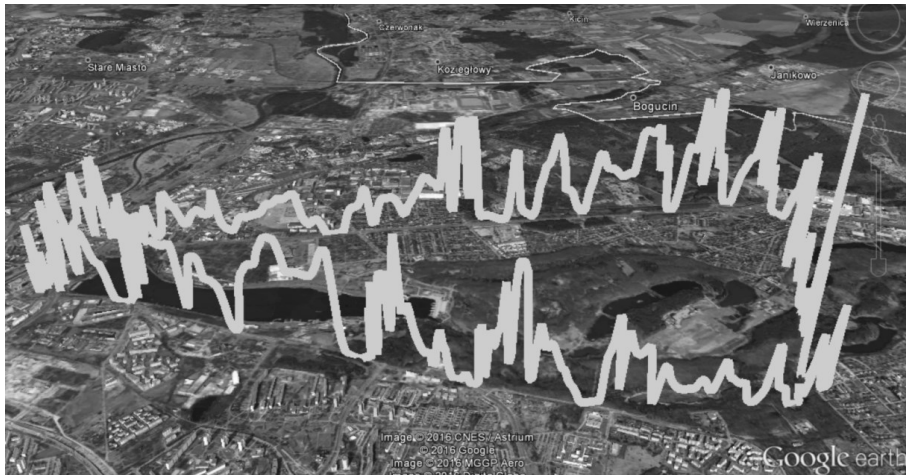


Fig. 7. Results of the  $\text{CO}_2$  emissions during economic drive



Fig. 8. Results of the CO emissions during economic drive

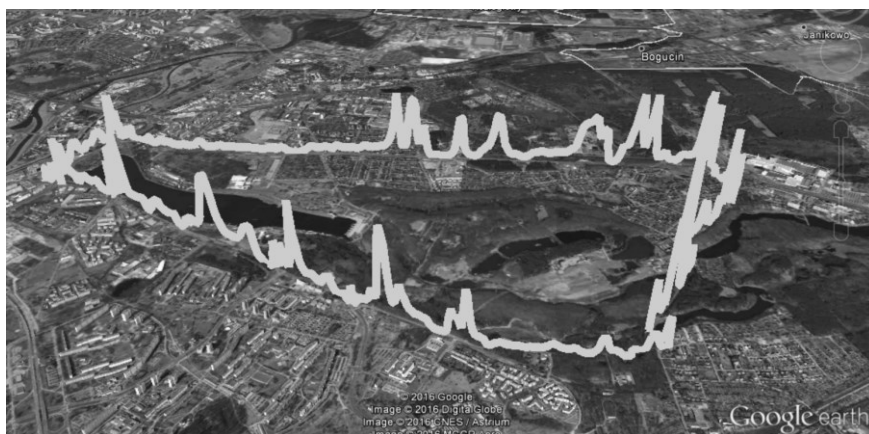
Fig. 9. Results of the NO<sub>x</sub> emissions during economic drive

Table 3. Comparison of the fuel consumption and emission levels of the tested vehicle compared emission standards

Data	Dynamic drive	Economic drive	Euro V limit
Fuel consumption [dm <sup>3</sup> /100 km]	10,8	8,31	10,6
Emission of CO [g/km]	0,194	0,087	0,5
Emission of NO <sub>x</sub> [g/km]	1,505	0,914	0,18

## 5. CONCLUSIONS

The conducted test drives under real operating conditions is the only method that allows for measuring the real impact of vehicles on the environment. The research presented in the article showed a significant excess of nitrogen oxides emissions. The effect that the driving style has on emissivity was also shown. As expected, aggressive driving, i.e. higher values of acceleration and speed of movement, have led to increased emissions of harmful compounds into the environment. Emissions of hydrocarbons have not been performed, as this involves transporting tanks with hydrogen in the car, and for a pick-up truck doing so would be dangerous in case of collision.

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## ANALIZA EMISYJNOŚCI POJAZDU TYPU PICKUP W RZECZYWISTYCH WARUNKACH EKSPLOATACJI

### Streszczenie

W artykule poddano analizie gazy wylotowe emitowane podczas ruchu pojazdu typu pickup. Sprzedaż pojazdów o tego typu nadwoziu zwiększa się obecnie zarówno na rynku krajowym, jak i europejskim. W ramach badań przeprowadzonych w Poznaniu, odbyły się dwa przejazdy autem – ekonomiczny i dynamiczny. Do badań posłużyła aparatura PEMS (*Portable Emissions Measurement System*) zamontowana na pojeździe Nissan Navara. Uzyskane wyniki przedstawiono w formie wykresów emisyjności naniesionych na mapę. Na podstawie porównania z obowiązującymi normami oraz podawanym przez producenta zużyciem paliwa sformułowano wnioski