THE EFFECT OF THE COMMERCIAL VEHICLE LOAD ON THE EXHAUST EMISSIONS

The aim of this study was to determine how the load of vehicle affects on the emissions of pollutants from the vehicle engine. Determinant were measurements of emissions of various pollutants in the exhaust gases in the real road conditions (and not only in laboratory conditions at the time of approval) with the use of a mobile equipment, that is new in the world. The article presents the results of road tests of commercial vehicle (LDV type) powered by compression ignition engine. The tests were conducted on the route between Poznan and Wrzesnia with the use of a portable exhaust emissions analyzers.

Key words: exhaust emissions, road tests, CI engine, commercial vehicle

1. INTRODUCTION

In the transport of passengers and cargo utility vehicles (that includes light duty trucks, tractor trucks and buses) play an important role. There are many types of these vehicles available worldwide of different load capacities limited by their gross vehicle weight (GVW). The source of drive of these vehicles in most cases are compression ignition engines that are characterized by high values of torque. As far as vehicles for the heaviest duties are concerned (of GVW greater than 16,000 kg) their engines are not only diesels but additionally of high displacement, which is a direct reason for high fuel consumption. This is a significant issue in terms of operating economy and profitability in the transport business. It thus makes a lot of sense to employ the vehicle’s load capacity to the maximum (maximum cargo load yet not exceeding the GVW) and avoid ‘empty runs’.

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The investigations described in this paper were conducted to assess the influence of the vehicle payload on the exhaust emissions – carbon oxides (CO, CO₂), hydrocarbons (HC), nitric oxides (NOₓ) and particulate matter (PM). The influence of the vehicle payload on the fuel consumption is easily measurable but in order to determine the exhaust emissions specialized test equipment is required [2].

2. RESEARCH OBJECT AND MEASURING EQUIPMENT

The tests under actual operating conditions were carried out on an LDV (Light Duty Vehicle). This was a Mercedes-Benz Vito fitted with a 4-cylinder 2.2 dm³ compression ignition engine (Fig. 1). In everyday operation it is used for carrying cargo of the total weight of 1000 kg. The complete kerb weight of the selected vehicle does not exceed 2610 kg, hence it belongs to a group of vehicles that are subject to the homologation tests on a chassis dynamometer according to the NEDC test (New European Driving Cycle) [1, 7]. The object of the investigations was not fitted with any aftertreatment systems such as oxycat or diesel particulate filter.

Fig. 1. The tested commercial vehicle – Mercedes-Benz Vito
In order to measure the exhaust emission of CO, CO₂, HC, NOₓ and PM, a portable exhaust emissions analyzers were used (Fig. 2 and 3). The equipment is composed of an array of special analyzers for the determination of the content of individual exhaust gas components. The system is composed of an exhaust gas flow meter (of different diameter depending on the engine displacement), a module connectable to the OBD system of a vehicle (On-Board Diagnostics) and a module connectable to the GPS system. Besides, the equipment apart from the measurement of the concentrations of the individual exhaust components measures mass flow of the exhaust gases, which is necessary to calculate the emissions of these components (road emissions or specific emissions, with a second sampling time resolution) [3].

![Fig. 2. The schematics of the exhaust emissions measuring equipment [4, 8]](image-url)
Fig. 3. Measuring equipment mounted on the vehicle: 
a) vehicle with load, b) vehicle without load

3. CONDITIONS OF MEASUREMENTS

The road exhaust emission tests were carried out under actual operating conditions on the route between Poznan and Wrzesnia (Fig. 4). The route was divided into three basic cycles differing in the traffic characteristics: urban (hereafter referred to as ‘City’), motorway (‘A2 motorway’) and mixed (‘National road No. 92’). The tests were carried out on the same route using a vehicle with and without a cargo. The vehicle payload was approximately 500 kg (including the testing equipment).

Fig. 4. The tested route (developed on the basis of Google Maps)
4. ROAD TESTS RESULTS

While performing the test drives the concentration of the exhaust components was measured on individual measurement road portions. The authors could thus determine the intensity of emission (mg/s) of these exhaust components for both the unloaded vehicle and the loaded one (Fig. 5-7). For the tested vehicle, on the whole test route (three measurement road portions) a significant increase in the emission was observed of carbon monoxide, carbon dioxide, hydrocarbons, nitric oxides and particulate matter while the cargo was transported. The greatest values were recorded for the urban conditions; this mainly results from high driving dynamics (frequent stops and abrupt accelerations) meaning a high energy demand of the vehicle engine.

Fig. 5. Emission intensity on the ‘City’ road part:
   a) carbon monoxide, b) carbon dioxide

Fig. 6. Emission intensity on the ‘A2 motorway’ road part:
   a) hydrocarbons, b) nitric oxides
Based on the measured concentrations of the exhaust components the road emission of CO, CO$_2$, HC, NO$_x$ and PM was calculated (Fig. 8 and 9). The obtained values of this emission confirm the observed relations on the time courses of the emissions (with second sampling time resolution).

Fig. 8. Road emission for the individual road part: a) carbon monoxide, b) carbon dioxide
The effect of the commercial vehicle load on the emission of harmful substances

The greatest increase in the road emissions for the drive with the cargo was recorded for the nitric oxides (Fig. 10). The emission of NO\textsubscript{x} calculated for the whole distance increased by approximately 17%.

As far as carbon monoxide is concerned its road emission during the drive with the cargo increased by almost 10% (for the urban road portion this was as much as 21%). Similar values are observed in the case of carbon dioxide and particulate matter. In the case of the last analyzed component (hydrocarbons) such a great increase has not been observed in its road emission. The emission of HC determined for the whole test route increased just a bit above 4%.

Fig. 9. Road emission for the individual road part: a) hydrocarbons, b) nitric oxides, c) particulate matter
5. CONCLUSIONS

The performed tests of a commercial vehicle (LDV type) under actual operating conditions have shown the influence of the vehicle load on the exhaust emissions. Having the above in mind it is noteworthy that very frequently observed carrying of unnecessary cargo in the vehicle may adversely influence not only the vehicle economy (fuel consumption; Fig. 11) hence the profitability of the transport operation but also the natural environment and humans [6]. An analogical situation will take place for light duty vehicle such as passenger vehicles where (similarly to utility vehicles) we can observe transporting unnecessary payloads. Hence, we should rationally approach the issue of necessary trunk item that are transported in the vehicle.

![Fig. 10. Comparison of the exhaust emissions for the entire test route](image)

![Fig. 11. Fuel consumption specified for the individual road portions](image)
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BIBLIOGRAPHY


Wpływ obciążenia ładunkiem pojazdu użytkowego na emisję substancji szkodliwych w spalinach

Streszczenie

Celem badań opisanych w artykułe była weryfikacja wpływu obciążenia pojazdu ładunkiem na emisję szkodliwych substancji w spalinach. Wykonano pomiary emisji szkodliwych składników spalin w rzeczywistych warunkach ruchu (a nie tylko w warunkach laboratoryjnych w trakcie tzw. homologacji typu) z wykorzystaniem mobilnej aparatury, co jest nowością w skali światowej. W artykułe zaprezentowano wyniki badań drogowych pojazdu użytkowego typu LDV napędzanego silnikiem ZS. Badania prowadzono na trasie między Poznaniem a Wrześnią z użyciem mobilnych analizatorów do badania emisji toksycznych składników spalin.