A METHOD OF PASSENGER CAR BRAKING AND CARBON DIOXIDE EMISSIONS

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Abstract

The article presents the results of road tests of the passenger car. The aim of this study was to determine the effect of variations in the vehicle braking methods on the carbon dioxide emissions. Inhibited using the gear ratios increase – less gear and using motion resistance while driving a rundown, in addition to using the brake system in the final stages of journeys made. The use of engine braking by drivers as a result of the reduction gear, for example during transport to the intersection, traffic light, railroad crossing, in place of the drive by coasting is particularly emphasized by the promoters of eco-driving. It is raised the issue of avoiding unproductive, from the viewpoint of the work efficiency of the engine, the engine idle speed.

The verification of environmental aspects of the use of engine braking was made because of the testing under real traffic conditions. Test drives were carried out at the measuring section, free from traffic. The test vehicle accelerates to a speed of 50 km/h, and then two ways of the speed deceleration were used. The values of the concentration of harmful carbon dioxide in the exhaust gases were achieved by using a mobile apparatus for testing exhaust emissions.

Keywords*: road transport, car braking, road tests, CO_2 emissions*

1. Introduction

Road transport, against all modes of transport, is subjected to the most stringent emission regulations concerning toxic compounds in the exhaust gases [2, 5]. Today, more and more emphasis is also to reduce carbon dioxide emissions. The CO_2 road emissions amounting 140 g/km means fuel consumption on the level of 6 dm^3/100 km, while amounting 120 g/km – just 5.2 dm^3/100 km [1]. Placing restrictions on road emission of CO_2 by 2015 means the average reduction in fuel consumption by 30% within ten years. Reducing this rate by 25% compared to the present value is, according to the European Commission, possible by new designs of engines, use of biofuels, new technologies of tires and air conditioning systems. German manufacturers (specializing in the production of large vehicles) suggested that the greater weight of the car automatically allowed for much higher ecological limits. Another view presented companies from Italy and France – as the smallest deviation from the accepted limit and significant penalties for its transgression [2].

Finally, the Commission proposed that new emission limit was only an average value for the entire car fleet. Heavier vehicles will have to comply with correspondingly higher limits

(e.g. 150 g CO_2/km for vehicles weighing more than 2000 kg). Companies will also be able to form themselves into groups, for example, Porsche could then calculate your average CO_2 emissions together with the manufacturer of small vehicles. Exceeding the limit emissions in 2012 cost 35 euros per 1 g of excess CO_2 emissions of each car [8].

The aim is not only to reduce CO_2 emissions in the exhaust of the vehicles, but also to reduce it throughout its "way of life" – from well to wheel. It is assumed that a suitable legislative policy in the next 20 years will reduce 3-5 times the total emissions of this compound from vehicles [2, 4]. This will be possible thanks to the introduction of another, stricter emission standards and integration laws in all countries.

The article presents the results of carbon dioxide emissions tests from passenger car belonging to segment B (hatchback) – according to the European cars grading, made in road conditions. It is contemplated the problem of the emission of this harmful exhaust compound with respect to the light-duty vehicles in terms of shaping method of driving in a range from standstill and the acceleration of the vehicle, obtaining a constant speed, then to stop the vehicle. It should be emphasized that the acceleration manoeuvre of the vehicle, and largely its dynamics, is responsible for the high fuel consumption and, associated with it, the most emitted carbon dioxide mass. However, the authors focused on identifying differences in carbon dioxide emissions in the final phase of the vehicle move (the so-called "non-drive" phase, when power is not supplied to the wheels of the vehicle).

As a result undertaken in the article analyses were obtained the results for the smallest environmental loads (emission of harmful CO_2) for two different ways of the vehicle braking: the so-called "engine braking" and from the use of the vehicle braking system in connection with engine idling. The aim of the study was to answer the question: how to stop the car to minimize carbon dioxide emissions. In order to determine the CO_2 content in the exhaust gases specialized mobile test apparatus PEMS type (Portable Emissions Measurement System) are used [6].

2. The object of research and instrumentation

Tests in real road conditions were conducted with the use of a PC type vehicle (Passenger Car). It was Skoda Fabia with 4-cylinder spark ignition (SI) engine with capacity of 1.4 dm^3 (Fig. 1). Other technical data of tested vehicle drive unit are as follows:

- cylinder number and configuration: straight 4,
- fuel injection system: Multi Point Injection (MPI),
- maximum power output: 50 kW at 5000 rpm,
- maximum torque: 120 N·m at 2500 rpm.

The tested vehicle propulsion system also includes a 5-speed manual gearbox. The vehicle was also equipped with an exhaust aftertreatment system, such as Three Way Catalyst (TWC).

For measuring concentration of CO_2 in the exhaust gases a portable system, PEMS was used. The system – Semtech-DS – consists mainly of the set of chemical analysers corresponding to given substances, the exhaust flow meter, the module recording data from the On-Board Diagnostics system (OBD) and the module for communication with the Global Positioning System (GPS) [7]. One of the analysers included in this equipment is the Non-Dispersive Infrared analyser (NDIR). It enables to determine, essential for the analysis conducted in the article, concentration of the carbon dioxide in the exhaust gases (NDIR measures also concentration of carbon monoxide) [3]. The Semtech-DS system also allows determining e.g. mileage fuel consumption for the tested vehicle utilizing so-called carbon balance method.

3. Road tests results

The use of engine braking by drivers as a result of the reduction gear, for example during transport to the intersection, traffic light, railroad crossing, in place of the drive by coasting is

particularly emphasized by the promoters of eco-driving. The issue of avoiding unproductive the engine idle speed, from the viewpoint of the work efficiency of the engine, is raised.

Fig. 1. Skoda Fabia prepared to the road tests

The verification of environmental aspects (emissions of carbon dioxide from the vehicle) of the application of the above-mentioned rules was made as a result of road tests of described above passenger car. Test drives were carried out at the measuring section, free from traffic. The test vehicle accelerates to a speed of 50 km/h, and then two ways of the speed deceleration were used. Inhibited using motion resistance while driving a rundown, in addition to using the brake system in the final stages of journeys made and using the gear ratios increase – less gear (Fig. 2). In this analysis, there is the concept of the "drive" and "non-drive" phases of the vehicle motion – when the power is delivered to the wheels of the vehicle, or not supply.

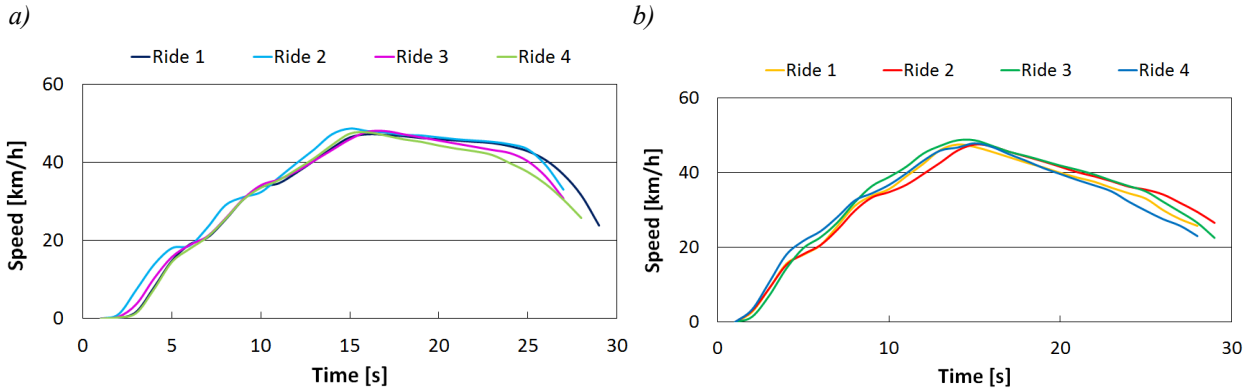

Fig. 2. The progress of the driving speed: a) engine idling, b) engine braking

In the case of carbon dioxide emitted by the tested car equipped with an SI engine, after obtaining the target speed and begin the process of deceleration can be seen a large increase its weight in the exhaust gases in the event of engine idling (the drive disconnect; Fig. 3a). In the case of engine braking weight increase of CO_2 in the exhaust gases, after stopping driving of the vehicle is much lower (Fig. 3b). This is due to significantly different developments of the intensity of carbon dioxide emissions (Fig. 4). Therefore – for the first one of used braking method the total mass of the carbon monoxide emitted from the tested vehicle drive system is in the range of 55–62 g, whereas for the second it amounts to 45–50 g (Fig. 5).

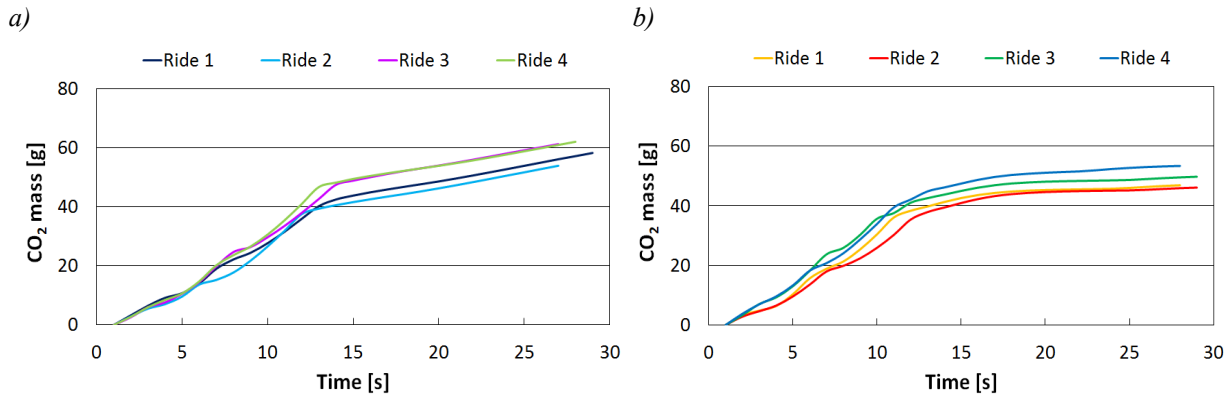

Fig. 3. Cumulative carbon dioxide emissions determined for engine idling (a) and engine braking (b)

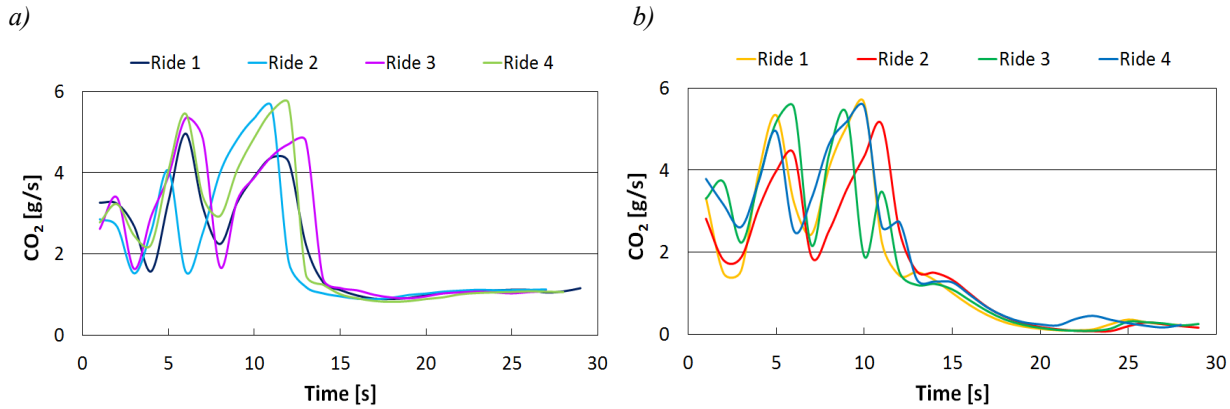

Fig. 4. The values of the intensity of carbon dioxide emissions: a) engine idling, b) engine braking

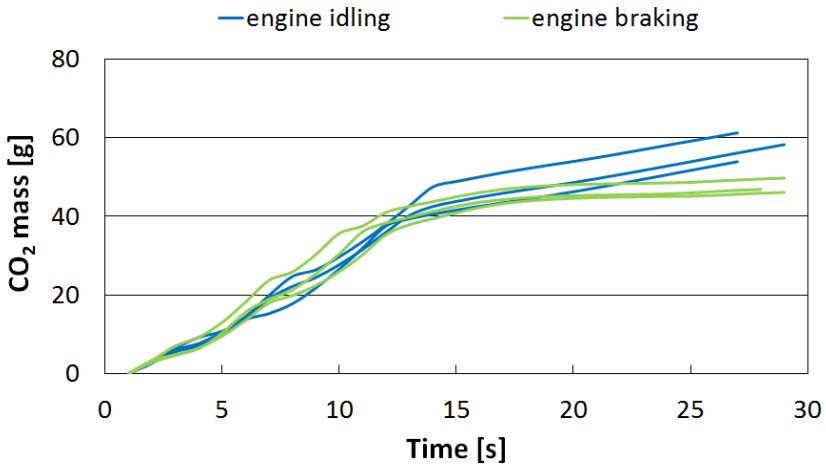

Fig. 5. The total mass of carbon dioxide obtained for the analysed driving techniques

The confirmation of previous results obtained specifying, for each ride, the road emissions of harmful exhaust component in the form of CO_2 (Fig. 6). Visible smaller or greater differences in the values of emissions are due to the degree of rides repeatability – especially important is the phase of driving the vehicle. It should be added that use of engine braking by the driver not only brings benefits in terms of lower emissions of CO_2 in the exhaust gases, but also in the form of lower fuel consumption (higher engine performance). Carbon dioxide emissions are in fact recognized in the so-called carbon balance method, serving just to calculate the fuel consumption of the vehicle.

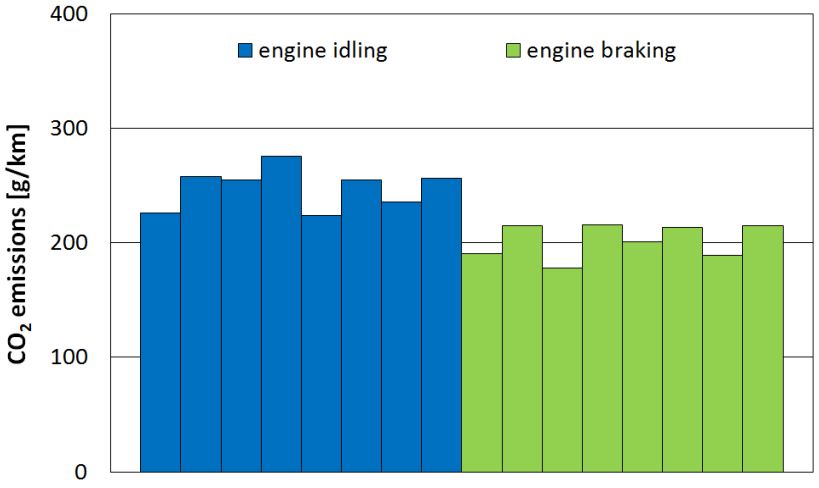

Fig. 6. The road emission of CO_2 determined for the analysed driving techniques

4. Conclusions

The carried out road tests showed the validity of the use of engine braking (downshifts) in place of driving a rundown during the operation of a motor vehicle. Not only that it avoids unproductive, from the standpoint of work efficiency, engine idling (lower mileage fuel consumption), it still achieved lower emission of harmful CO_2 in the exhaust gases.

The use of engine braking in place of a rundown driving also contributes, in addition to the environmental aspects, to less brake components wear and increase the safety of transport – the issue of long disconnecting the drive in case of rundown driving. In particular, this applies to all downhill rides, where there is a high danger of overheating of the braking system.

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