EUROPEAN REGULATIONS, CO_2 EMISSIONS LIMITS AND FUEL CONSUMPTION OF ENGINES FUELLED BY BIOFUELS

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Rezumat. Lucrarea analizează multiplele relații, reglementate, dintre limitele emisiilor (incluzând dioxidul de carbon) motoarelor autovehiculelor alimentate cu biocombustibili și consumurile de combustibil ale acestora. Cercetarea a fost extinsă atât la autovehiculele vechi, aflate încă în circulație, cât și la autovehiculele actuale. Specificațiile de calitate ale biocombustibililor au fost , de asemenea, corelate cu emisiile și consumurile autovehiculelor noi și actuale. În cercetările experimentale au fost utilizați diferiți biocombustibili pentru a estima influențele asupra emisiilor de CO_2 și consumului de combustibil. Una din principalele contribuții ale lucrării este sublinierea rolului dezvoltării de noi tehnologii în reducerea emisiilor de CO_2 ale motoarelor autovehiculelor.

Cuvinte cheie: reglementări europene, limite de emisii, consum de combustibili, motoare alimentate cu biocarburanți, emisie de dioxid de carbon.

Abstract. The paper analyze multiple regulate relationships between biofuels feed car-engines emissions limits (including CO_2 emissions) and fuel consumption. The investigation were extends both to older petrol engines powered cars and today petrol engines powered cars. Fuel quality specifications were also correlated to emissions and fuel consumption of actual and older cars fuelled by biofuels. Different biofuels was used in experimental research for estimate the influence over engine CO_2 emissions. One main contribution of this paper is the emphasis of the role of technology improvement in continuously diminishing of CO_2 car-engine emissions.

Keywords: European regulation, emissions limits, fuel consumption, biofuels fuelled engines, carbon dioxide emission.

1. INTRODUCTION

European emission standards define the acceptable limits for exhaust emissions of new vehicles sold in EU member states. The emission standards are defined in a series of European Union Directives staging the progressive introduction of increasingly stringent standards [1].

Currently, emissions of nitrogen oxides (NO_x), total hydrocarbon (THC), non-methane hydrocarbons (NMHC), carbon monoxide (CO) and particulate matter (PM) are regulated for most terrestrial vehicle types. For each vehicle type, different standards apply. Compliance is determined by running the vehicle at a standardized test cycle. Non-compliant vehicles cannot be sold in the EU, but new standards do not apply to vehicles already on the roads. No use of specific technologies is mandated to meet the standards, though available technology is considered when setting the standards. New models introduced must meet current or planned standards, but minor lifecycle model revisions may continue to be offered with pre-compliant engines. The vehicles chemical toxic emission stages and European legal framework are brief describes in the followings.

The stages are typically referred to as Euro 1, Euro 2, Euro 3, Euro 4 and Euro 5 for Light Duty Vehicle standards. The corresponding series of standards for Heavy Duty Vehicles use Roman, uses rather than Arabic numerals (Euro I, Euro II, etc.) [1].

The legal framework consists in a series of directives, each one as amendment to the 1970 Directive 70/220/EEC. Below is a summary list [1] of the standards, when they come into force, what they apply to, and which EU directives provide the definition of the standard:

1) Euro 1 (1993): for passenger cars - Directive 91/441/EEC; also for passenger cars and light trucks - Directive 93/59/EEC;

2) Euro 2 (1996): for passenger cars - Directive 94/12/EC (& Directive 96/69/EC); for motorcycle - Directive 2002/51/EC - Directive 2006/120/EC;

3) Euro 3 (2000): for any vehicle - Directive 98/69/EC; for motorcycle - Directive 2002/51/EC - Directive 2006/120/EC;

4) Euro 4: (2005) for any vehicle - Directive 98/69/EC (&Directive 2002/80/EC);

5) Euro 5 (2008/9) and Euro 6 (2014): for light passenger and commercial vehicles - Directive 715/2007/EC.

In the table 1 are presented the chemical emission limits in respect for each directive above mentioned.

Table 1

European emission standards for passenger cars (Category M*), g/km [1]

Tier	Date	CO	THC	NMHC	NO_x	HC+NO_x	PM	P***
Diesel								
Petrol (Gasoline)								
Euro 1†	July 1992	2.72 (3.16)	-	-	-	0.97 (1.13)	-	-
Euro 2	January 1996	2.2	-	-	-	0.5	-	-
Euro 3	January 2000	2.3	0.20	-	0.15	-	-	-
Euro 4	January 2005	1.0	0.10	-	0.08	-	-	-
Euro 5	September 2009	1.0	0.10	0.068	0.060	-	0.005**	-
Euro 6 (future)	September 2014	1.0	0.10	0.068	0.060	-	0.005**	-

* Before Euro 5, passenger vehicles > 2500 kg were type approved as light commercial vehicles N1-I.
** Applies only to vehicles with direct injection engines.
*** A number standard is to be defined as soon as possible and at the latest upon entry into force of Euro 6.
† Values in brackets are conformity of production (COP) limits.

As one can see in Table 1, since the Euro 2 stage, EU regulations introduce different emission limits for petrol engine powered vehicles. Petrol-powered vehicles are exempted from particulate matter (PM) standards through to the Euro 4 stage, but vehicles with direct injection engines will be subject to a limit of 0.005 g/km for Euro 5 and Euro 6. A particulate number standard (P) or (PN) is part of Euro 5 and 6, but is not final. The standard is to be defined as soon as possible and at the latest upon entry into force of Euro 6. All dates listed in the tables refer to new type approvals. The EC Directives also specify a second date — one year later — which applies to first registration (entry into service) of existing, previously type-approved vehicle models [1].

In the area of fuels, the 2001 Biofuels Directive requires that 5.75% of all transport fossil fuels (petrol and diesel) should be replaced by biofuels by 31 December 2010, with an intermediate target of 2% by the end of 2005. However, MEPs have since voted to lower this target in the wake of new scientific evidence about the sustainability of biofuels and the impact on food prices. In a vote in Strasbourg, the European parliament's environment committee supported a plan to curb the EU target for renewable sources in transport to 4% by 2015. They also said that a thorough review would be required in 2015 before the EU could progress to an 8-10% mark by 2020 [2].

In December 2008 the European Parliament and Council reached an agreement through a co-decision procedure on the details of the CO_2 legislation for passenger cars, laid down in Regulation (EC) 443/2009. Besides the target of 130 g/km for 2015 and details of the way it is implemented, Regulation No 443/2009 also specifies a target for the new car fleet of 95 g/km for the year 2020. A similar regulation has been implemented for light commercial vehicles (Regulation (EU) 510/2011), setting a target of 175 g/km for 2017 and of 147 g/km for the year 2020. Both regulations are currently undergoing amendment in order to implement the 2020 targets. In July 2012 the European Commission published their proposals for the modalities for implementation of these targets for passenger cars (COM(2012) 393) and vans (COM(2012) 394). Implementation of new technologies and improvements of existing technologies are the main instruments for a manufacturer to achieve these CO_2 emission goals [3].

2. CO_2 AND FUEL CONSUMPTION IN LAWFUL EUROPEAN FRAMEWORK

The measurement of fuel consumption and CO_2 emissions has become mandatory during the type approval procedure for M1 vehicles (cars) in the EU with the introduction of directive 93/116/EC [4]. Within the context of the discussions about the global warming of the atmosphere the lowering of the CO_2 emissions and thus the lowering of the fuel consumption has become an important target for the vehicle industry.

The fuel consumption, expressed in liters per 100 km in the case of petrol positive-ignition engines is calculated by means of the following relation [4]:

$$FC = (0.118/D) \cdot [(0.848 \cdot HC) + (0.429 \cdot CO) + (0.273 \cdot CO_2)], \quad (1)$$

where: *FC* is petrol engine fuel consumption (in l/100 km); *D* is fuel density (in $10^{-3} \cdot g/dm^3$); HC, CO, CO_2 are hydrocarbons, carbon monoxide and carbon dioxide quantities from exhaust engine gases (in g/km).

From (1) we can obtain:

$$CO_2 = (FC \cdot D/0.118 - 0.848 \cdot HC - 0.429 \cdot CO)/0.273 \quad (2)$$

Relations (1) and (2) operate in conditions of [5] including reference fuel (Petrol/Gasoline E5).

For the goals of this paper, using together with reference unleaded petrol fuel (E0) we was used relation from [6] as follow:

$$CO_2 = (FC \cdot D \cdot 0.85 - 0.866 \cdot HC - 0.429 \cdot CO)/0.273, \quad (3)$$

where FC, D, HC, CO and CO_2 are the same as in relation (1).

For the aim of this paper we calculate CO_2 emissions for both older (after 1993) cars and today cars in followings assumptions:

1) all the cars are powered by petrol positive-ignition engines;

2) all the cars are in good technical condition, emission for each one do not exceed correspondent EURO limits;

3) for CO_2 emission calculus each engine operate with HC and CO values in engine exhaust gases like EURO correspondent Table 1 values;

4) each vehicle was link with an amount of fuel consumption. Fuel consumption was varied from 3.9 to 14 (l/100 km) with 0.5 l/km steep;

5) CO_2 emission was calculates for both E5 petrol fuel (with relation (2)) and E0 petrol (with relation (3);

6) was made also difference between petrol E5 CO_2 emission and petrol E0 CO_2 emission, for each vehicle (amount of fuel consumption);

7) we assume not engine trouble by ethanol from E5 petrol for older cars.

3. RESULTS

In Figures 1-5 we presents the results of CO_2 emissions calculus (for cars with engines fuelled by E5 and E0) and for differences between CO_2 emissions.

If each amount of fuel consumption is associate by a car, in above hypothesis, the amount of calculate CO_2 was represent „best case" for each vehicle operating CO_2 emission.

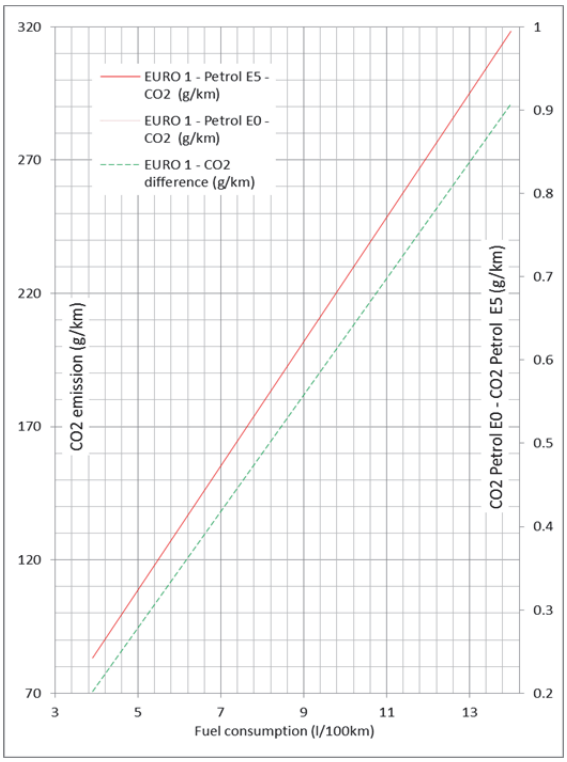

Fig. 1. CO_2 emissions for EURO 1 cars.

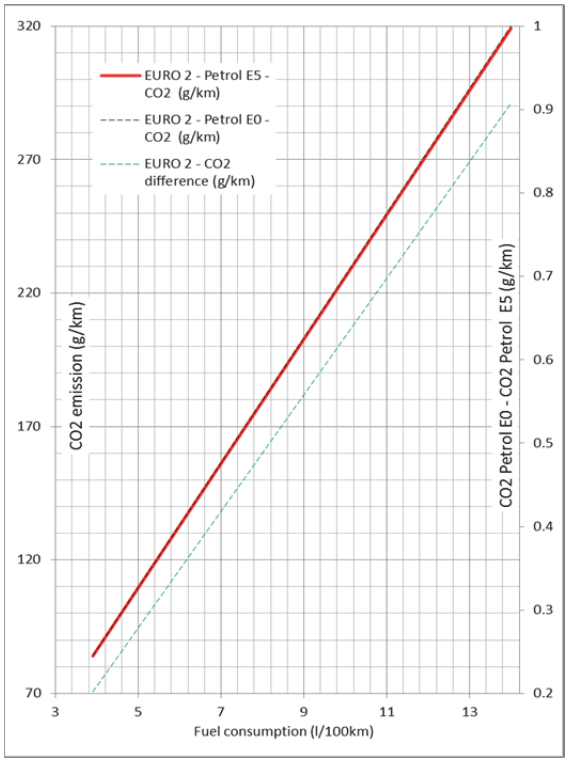

Fig. 2. CO_2 emissions for EURO 2 cars.

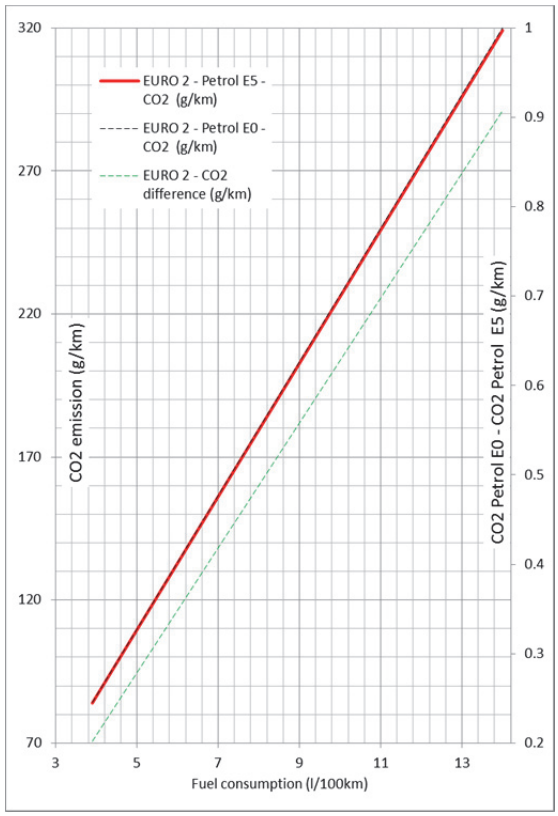

Fig. 3. CO_2 emissions for EURO 3 cars.

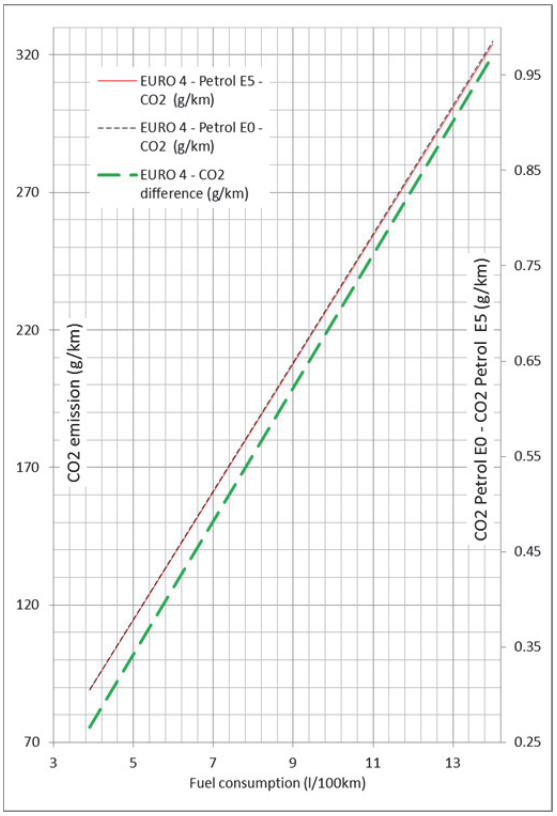

Fig. 4. CO_2 emissions for EURO4 cars.

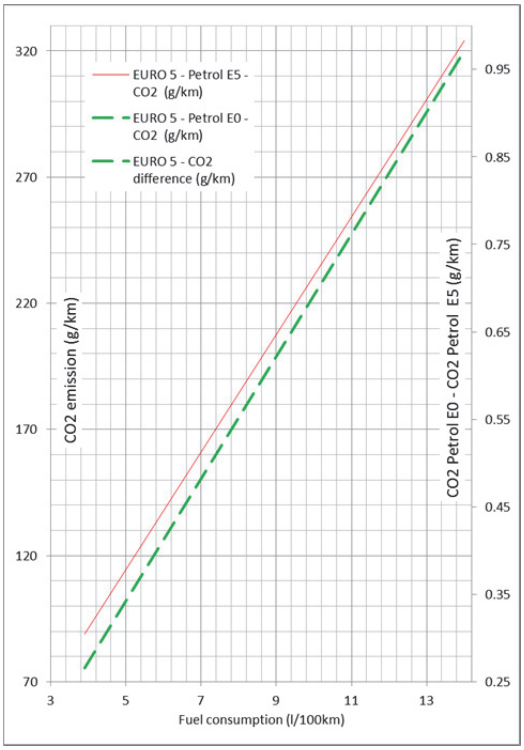

Fig. 5. CO_2 emissions for EURO5 cars.

4. CONCLUSIONS

The paper analyze multiple regulate relationships between car-engines positive ignitions emissions limits (including CO_2 emissions) and fuel consumption. The investigation were extends both to older petrol engines powered cars and today petrol engines powered cars. Fuel quality specifications were also correlated to emissions and fuel consumption of actual and older cars with petrol positive-ignition engines**.**

If all carbon of fuel combust into CO_2, in cylinder engine, the combustion of air-fuel is complete and engine efficiency is a maximum value. In this case in exhaust gasses can find only carbon dioxide, water and nitrous oxides. This is an ideal case a „worst case" from point of view of CO_2 emissions.

Main conclusions of paper are:

- For an older car, with same fuel consumption as a new car, the CO_2 emissions are lowest than CO_2 emissions of new car.
- New technologies and materials can reduce fuel consumption and, in the same time, CO_2 emissions.
- Reference drives cycle affect CO_2 emissions. Gear shift strategy, driver behavior an use of air conditioning system also have influence on CO_2 emissions.
- Fuel qualities affect direct the amount of CO_2 emissions. For older car, using E5 or E10 fuels, if no technical trouble occurs, feeding by E5 or E10 can mean an important reduction of CO_2 emissions.
- The main way for reduce CO_2 emissions remain the diminishing of engine fuel consumption.

REFERENCES

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