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THE IMPACT OF DIESEL ENGINE PARAMETERS OVER THE POLLUTANT EMISSIONS AND THEIR USE IN A CALIBRATION STRATEGY

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Abstract: *The car is one of the main sources of pollution to the environment, its contribution to global pollution is between 20% and 30% in the industrialized countries. In this context the development of an economic engine designed for road traction is a prime concern. Society has understood that a "harmful friend" has to be converted into one less harmful, and finally in one more friendly with the man and the environment, in general. The paper work presents the preliminary experimental research references developed on a Renault K9K engine (1461 cm^3). The purpose of this preliminary research is to develop a specific calibration strategy in order to reduce the fuel consumption and CO_2 emissions. The researches were conducted on two specific areas of the New European Driving Cycle (N.E.D.C.): a characteristic urban phase at 50 km/h and an extra urban phase at 120 km/h.*

Keywords: CO_2 emissions, injection advance, injection pressure, pollution, calibration.

INTRODUCTION

Reducing the impact automobile-environment is currently a major concern for all the automotive specialists. Today the auto industry is under pressure, determined by the contradictory requirements as: chemical and sound pollution, fuel consumption, driving safety, comfort, costs, integration in transportation systems, performance and drivability. All these constitute barriers hard to overcome and require extensive expenses and intellectual effort.

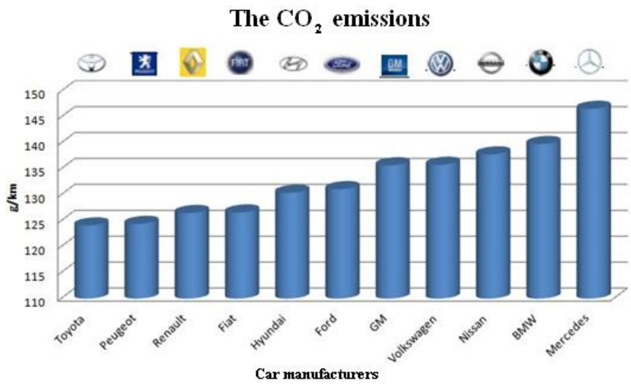

Figure 1. The CO_2 emissions of the main car manufacturers

An important step for controlling CO_2 emissions consists in ratification of the Kyoto Protocol which obliges the members of industrialized countries to reduce the amount of

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greenhouse gases emitted into the atmosphere. This ratification was born in Kyoto, Japan, in December 1997 as an amendment to the United Nations Convention on Climate Change (United issue Framework Convention on Climate Change -UNFCCC). It remains the most comprehensive international agreement, nowadays with 187 signatory countries, which has as target to reduce emissions with 5.2%, between 2008 and 2012, compared with the reference level reached in 1990 [1].

In this context, the European Commission proposed limitation of carbon dioxide emissions for cars up to 95 g/km in 2020, with a compulsory goal of 130g/km until 2015.
Therefore the cost of the implementation of the new systems of emissions reduction is almost entirely amortized by the fuel economy or by reducing other expenditure and operating tax.

The Regulation EC443/2009 to C. A. F. E. (Corporate Average Fuel Economy) requires cars manufacturers a reduction of emissions for all new vehicles sold in Europe.[2] Regarding this aspect in figure 1 are shown the CO_2 emissions of the major car manufacturers in the year 2012.

To achieve these ambitious goals of reduction in fuel consumption is necessary to reduce the engine displacement and the adoption of processes which are leading to the continual improvement of the combustion process.

POSSIBILITIES OF REDUCING INJECTED FUEL AND PRELIMINARY EXPERIMENTAL RESULTS

Experience has shown that changing functional engine parameters: the air flow, the boost pressure, the injection advance etc., has an influence on the quantity of chemical pollutants from the exhaust gases and especially CO_2 emissions.[3] (Table 1)

Table 1. The effect of the engine's functional parameters for the pollutant emissions[4][5]

	The effect on pollutant emissions				
The parameters which are growing	HC	CO	NO_x	P.M.	CO_2
Air Flow	↘	↘	↗	↘	↘
Turbo charger pressure	↘	↘	↘	↗	↗
Injection Advance	↘	↘	↗	↘/↗	↘
The injection pressure	↘	↘	↗	↘	↘
Pilot injection flow rate	↘	↘	↗	↗	↘

Synthesizing, the impacts of these parameters are shown below:

The air flow available for the formation of the mixture (Q_{am}) is fresh air Q_a (including the exhaust gases sucked during the period of overlapping opening valves – internal EGR) and exhaust gases admitted via E.G.R. (Exhaust Gas Recirculation) system to provide NO_x reduction (Q_{EGR}).

$$Q_{am} = Q_a + Q_{EGR} \tag{1}$$

Usually, for an engine operating point the goal is to reduce CO_2 emissions by increasing the air flow without compromising the quality of the combustion process.

The boost pressure, used to obtain a curve of maximum torque, is correlated with the air flow entering in the engine. For some engine's speeds, such as the maximum torque speed, the amount of E.G.R. is reduced to zero therefore we obtain the equation 2:

$$Q_{am} = Q_a \tag{2}$$

Obviously the reduction of Q_{EGR} implies an improvement in the efficiency of the combustion process which allows the reduction of the CO_2 emissions.

Injection advance. As noted in table 1, the injection advance plays a decisive role to reduce the CO_2. This parameter is tuned taking into account the following aspects:

- the available time to create the fuel mixture;
- the noise's level;
- the contact of the fuel jet with the walls of the combustion chamber.

The injection pressure reduces the CO_2 emissions by the achievement of high homogeneity of the fuel spray in the cylinder volume thereby increasing the efficiency of combustion. Experience has shown that the rail pressure must be correlated in an appropriate way with the engine's speed in order to achieve a reduction of CO_2 emissions.

Usually this parameter can vary from 250 bar for low load and speed, up to 1800 bar for full engine's loads. [6]

Pilot injection's flow rate determines the increase of temperature and pressure before the main injection so we get a higher combustion efficiency which is reflected in a successful economy, a default emissions reduction of CO_2.[7]

To get an overview of economical gain by changing the injection pressure and advance, we have made a modification of these functional parameters on two zones of the N.E.D.C. (New European Cycle Driver) driving cycle: steady state corresponding to a speed of 50 km/h, phase specific to the urban cycle, and steady state corresponding to a speed of 120km/h, specific to an extra-urban driving sequence.[8]

Experimental tests have been obtained on a turbocharged diesel engine mid-range, with 1500 cm^3 displacement equipped with a direct injection with common rail system.

The main design parameters of the engine are 80.5 mm stroke, 76 mm bore, and 15.7 compression ratio. The engine develops 80 kW at 4000 rpm and a maximum torque of 240 Nm at 1750 rpm.

Below are graphical influences of injection pressure and injection advance on the CO_2 emissions for each of the vehicle speeds previously mentioned.

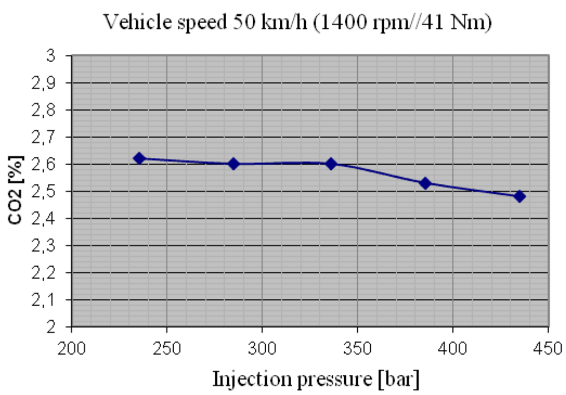

Figure 2. CO_2 emissions in percentages depending on the injection pressure

for the vehicle speed of 50 km/h.

It is observed that by increasing the injection pressure from 330 to 440 bar the CO_2 emissions are reduced by 0.1 per cent. In the same time the trend curve shows that a high injection pressure reduces the CO_2 emissions (figure 2).

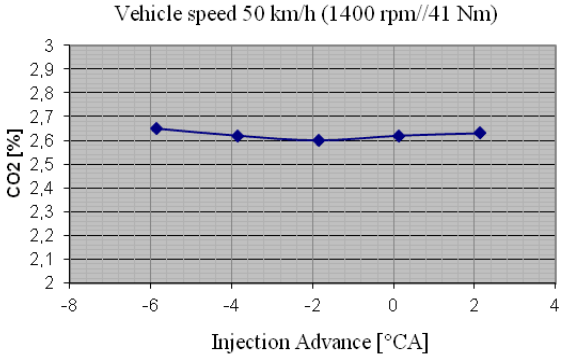

Figure 3. CO_2 emissions in percentages depending on the modification of the injection advance for the vehicle speed of 50 km/h

In figure 3 the scavenging of the injection advance reveals a gain of 0.05 percent for a shifting value of -2 [°CA]. Unlike the figure 2, where it could continue an increase in the value of injection pressure in an attempt to reduce CO_2 emissions, an increase of the advance over the value of -2 [°CA] is not indicated because the graph of CO_2 has an upward trend.

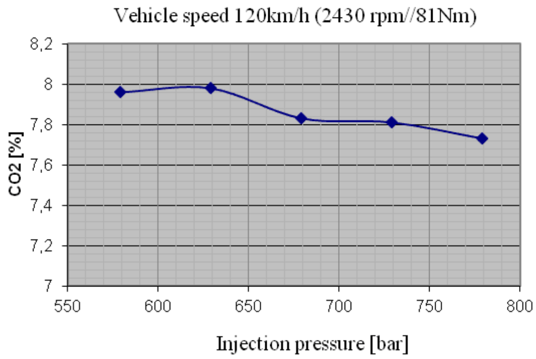

Figure 4. CO_2 emissions in percentages depending on the injection pressure for the vehicle speed of120km/h

For a higher engine speed, corresponding to 120 km/h, the gain of CO_2 emissions by modification of the injection pressure (figure 4) is 0.3 percent.

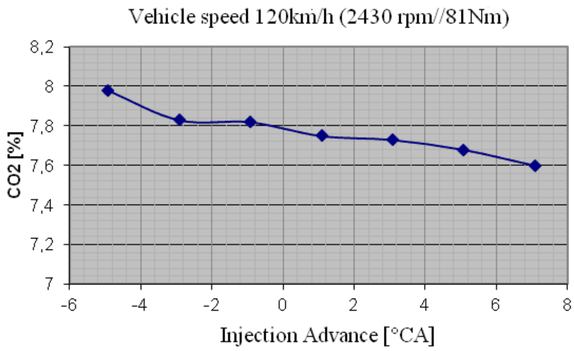

Figure 5. CO_2 emissions in percentages depending on the modification of the injection advance for the vehicle speed of 120km/h

At the same vehicle speed it is observed that changing the injection advance determinate a reduction in the CO_2 emissions of 0.4 percent. It can be concluded that in the full load and higher engine speeds the increase of the injection advance has a more pronounced impact than the injection pressure.

These functional influences are leading to the following conclusions regarding the development of a calibration strategy.

CONCLUSIONS

The examinations of the experimental results reveal:

- In the urban cycle of NEDC, by cruising at a constant speed of 50 km/h, we obtain a reduction of CO_2 with 0.1 percent by increasing the injection pressure with 100 bar (figure 2). In the case of the injection advance modification we have register a decrease in emissions of CO_2 with 0.05 percent for an increase of 4 [°CA] (figure 4).
- Reducing consumption in extra urban cycle was more pronounced at 120 km/h. On this point the increase of the injection pressure with 150 bar leads to a reduced CO_2 emissions quantity with 0.3 percent (figure 4). Modification of the advance with 12[°CA] give us a decrease with 0,4% of CO_2 emissions.
- Keeping in mind the impact of advance and injection pressure over the CO_2, in the two N.E.D.C. phases it is easy to observe:
  - on the urban cycle the best results concerning the reduction of CO_2 are obtained by increasing the injection pressure;
  - on the extra-urban cycle the modification of injection advance has the most powerful impact for reducing the CO_2 emissions.
- The influence of engine parameters, represented in the preliminary experimental results, allows establishing a strategy in terms of engine calibration regarding the reduction of CO_2 emission.

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