COMPARISON OF THE EFFECTS OF INDIVIDUAL AND PRODUCTION ADJUSTMENT OF VEHICLES FOR LPG APPLICATION

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Abstract: *The paper presents the results of developmental researches related to determining the influence of application of various systems for LPG on vehicle properties. On model Florida Zastava the following sequential systems were installed: Sequent 24 BRC, Omegas LR, e-G@S, Fast Lovato and Alisei N Zavoli. The results of comparative investigations obtained indicate the advantages of particular systems. The results of individual adjustment have been compared with the results of a production vehicle adjustment.*

Keywords: VEHICLE, LPG, SEQUENTIAL SYSTEMS.

1. Introduction

Fossil fuels (around 99%) are still dominant as drive fuels for automobile engines, in spite of many attempts to introduce other alternative fuels (LPG, CNG, alcohol, hydrogen and others). In this paper, some experience in applying liquid petroleum gas and compressed natural gas on vehicles, as alternative fuels for dual drive, will be considered. All vehicles which use liquid fuels can be adjusted to application of gas, in bi-fuel systems. Which of the systems for LPG/CNG will be applied depends on the purpose of vehicle and type of main fuel. Long-term decision is that bi-fuel systems are applied on petrol engines. The main property of these systems is that engine is activated only by petrol or gas, according to attuned device, driver's desire or available fuel. The paper has analysed systems with gas injection applied on vehicles with plastic intake manifold. System for gas injection consists of the following important elements: electronic control unit (ECU), swich indicator, gas filter, gas pressure regulator, injector rail, gas temperature and pressure sensor.

To the existing electronic control unit of the system for petrol injection one more electronic unit is added, which makes the connection with the existing petrol system. System for gas injection is the system of new generation of dual systems (petrol-LPG/CNG). System for gas makes possible injecting of gas into each intake manifold separately. According to defined procedure, the engine starts functioning with fuel at start, and after certain period of time or achievement of given temperature the control unit switches the engine functioning to gas. The principle applied by electronic control unit for gas is calculating of injection time applied on gas injector. Control of engine is given to petrol electronic control unit, while electronic control unit for gas turns that information into suitable control form for gas. New gas systems can use different types of injectors in dependence on application conditions. Electronic control unit for gas calculates the time of gas injection by using specific information, such as pressure in injector, gas temperature, cooling liquid temperature, number of engine revolutions as well as input data of petrol electronic control unit (ECU).

In systems with auto-calibration, the initial adjustments are realized at a standstill, too, after installing the system for gas in vehicle. In general, the adjustment of system configuration is realized when the engine is not running. After that, the auto-calibration procedure is started, where adjustment is performed according to the demands of the system producer. After the completion of auto-calibration procedure, each system will define its system map. The map is constructed on the basis of two pieces of data: engine rpm and petrol injection timing. In case that you are not satisfied with auto-calibration, possible modifications can be realized by optimization of map value on gas, i.e. map coefficients loaded during automatic calibration process, both at minimum and beyond idle stroke range.

2. The application of sequential systems for LPG

When selecting the sequential system for LPG, the following must be taken care of:

- That the system for gas is homologated according to valid regulations.
- That the gas tank with strengthening must also be homologated according to valid regulations; in addition to that, gas tank must satisfy the time condition for safe installing.

At the market, there is a wide range of sequential systems for gas injection, produced by both the leading system producers and the unsuccessfully licensed and new producers. The worst version is when the installer composes the system himself, without any examinations and tests. That is especially bad when performed by a bad installer with the false aim of making it less expensive. Based on previous experience in the application of vacuum gas systems and on market offers, the following systems for gas injection were selected for developmental investigations: Sequent 24 BRC, OMEGAS Landi Renzo, e-G@S, Fast Lovato, Alisei N Zavili.

All the systems were installed into the engine compartment; tank with support was installed into luggage compartment, while the commutator for the selection of fuel type was installed on the dashboard. The proposed solutions for installing the gas system should provide:

- additional installing of optional drive units on the vehicle (A/C, servo controller etc.)
- standardized installing for all the versions of one vehicle model
- standardization of parts which are to be installed.

Fig. 1 *Vehicle Florida 1.6 In L- OMEGAS Landi Renzo*

Fig.1 shows the installing of device OMEGAS Landi Renzo. ECU for gas is installed next to the petrol one. The injectors are installed on the upper side. Vaporizer is connected to the car battery support. The final aim is standardization of the linking point of gas system elements, within limits of the observed vehicle model.

Basic regulation is performed without load, at a standstill:

- at idle stroke
- at 3000o/min.

The recommendation is to carry out the necessary corrections in driving after each basic adjustment.

3. Analysis of the influence of applying various systems for gas

With the aim of determining the effects of application of various systems, the following investigations are realized:

- properties of engine/vehicle which uses petrol/LPG
- properties of engine/vehicle with various systems for LPG.

3.1 The investigation of vehicles on dynamometer rolls

The paper includes the investigation of vehicles on dynamometer rolls, Fig.2, with the aim of determining the effects of application of various systems for LPG.

Fig. 2 *Investigations of vehicles on rolls*

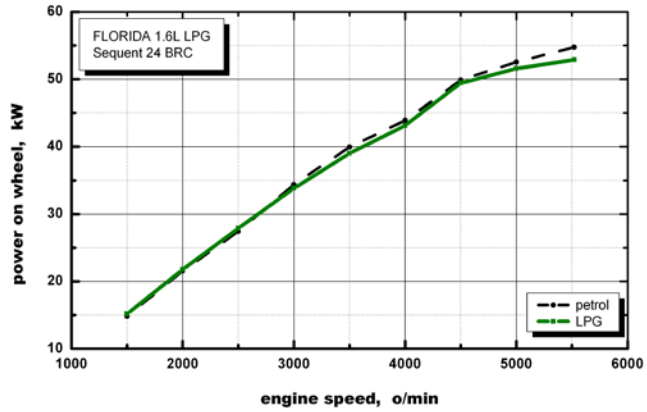

Fig. 3 *Florida In 1.6L –Sequent 24 BRC*

The selected methodology for measuring power on vehicle wheel provides fast and accurate comparative measuring with the aim of observing the influence of various changes on force-speed properties of the vehicle. The procedure makes it possible to use the measured values in order to calculate the external speed property of the engine. Owing to the applied adjustment of measuring to standard conditions, good comparability of the results is provided, because varying of important factors is eliminated.

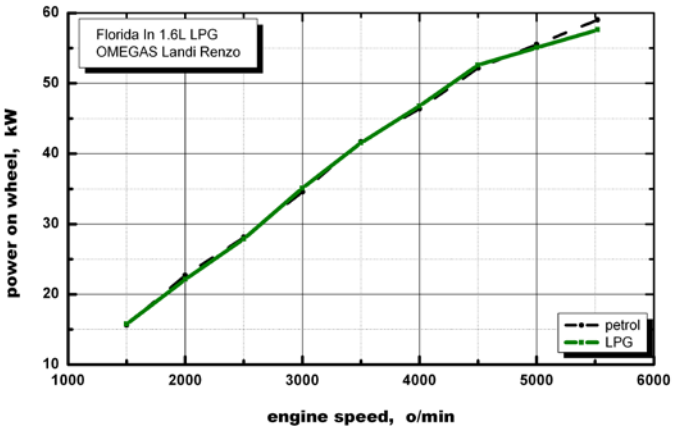

Fig. 4 *Florida In 1.6L- OMEGAS LR*

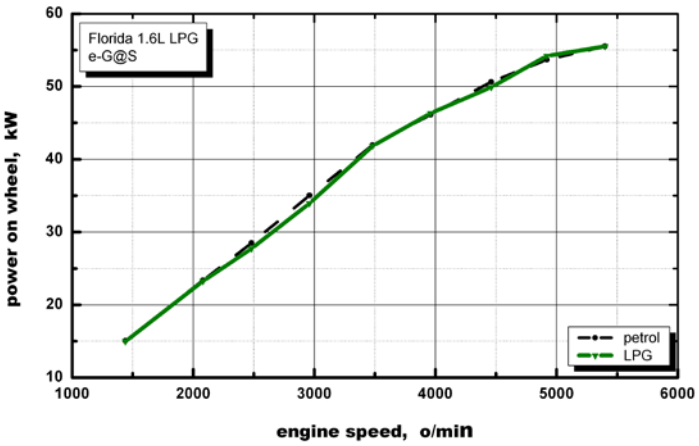

Fig. 5 *Florida In 1.6L- e-G@S*

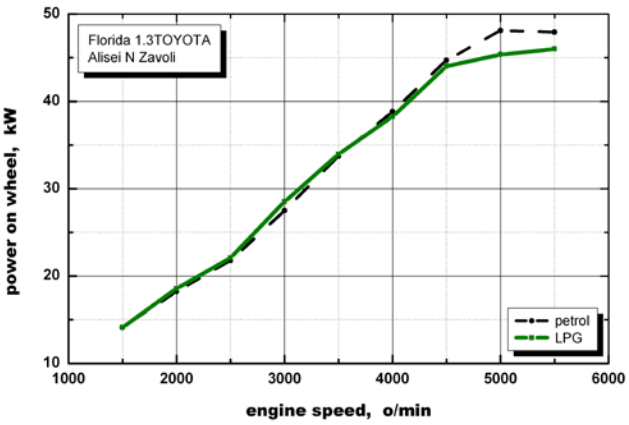

Fig. 6 *Florida 1.4- Alisei N Zavoli*

Fig. 3, 4, 5 and 6 show the effects of application of various systems on vehicle Florida, with multipoint system for petrol, which satisfies Euro III. Different systems are programmed in different ways and they provide different results. At smaller r.p.m. mainly all systems for gas function well. At higher r.p.m. the differences are obvious, especially in programming without correction. Persistent correction of adjustments can lead to the desired congruence of behaviours when using petrol and LPG, but that should not be the only aim.

3.2 Exploitation investigation of vehicles

When optimizing the programming process, the initial adjustment must be corrected by measuring made on engine brake, on dynamometer roll and, subsequently, in exploitation conditions. Exploitation investigations included:

- Comparative measuring of maximal speed with petrol – LPG

- Comparative measuring of acceleration with petrol – LPG
- Comparative measuring of elasticity with petrol - LPG
- Comparative measuring of consumption petrol - LPG (mixed test, urban driving)
- Optimization of system operating
- Recording of performances.

Comparative measuring of maximal speed with petrol/LPG. A sequential system for gas injection OMEGAS Landi Renzo was installed into the vehicle Florida In 1.6L. This vehicle behaved almost identically with LPG as with petrol.

Table 1: *Maximal speeds – comparative display.*

Vehicle	V_0=0 km/h		V_0=40 km/h	
	petrol	LPG	petrol	LPG
Florida In 1.6L	167,6	165,97	164,6	164,7

Comparative measuring of acceleration and elasticity with petrol/LPG. Table 1 and Fig. 7 show the comparative results of acceleration measuring (0 - 120km/h). A minor degradation of speed occurred with LPG drive. As for elasticity measuring, Fig.8, congruence with LPG drive was even better than with petrol.

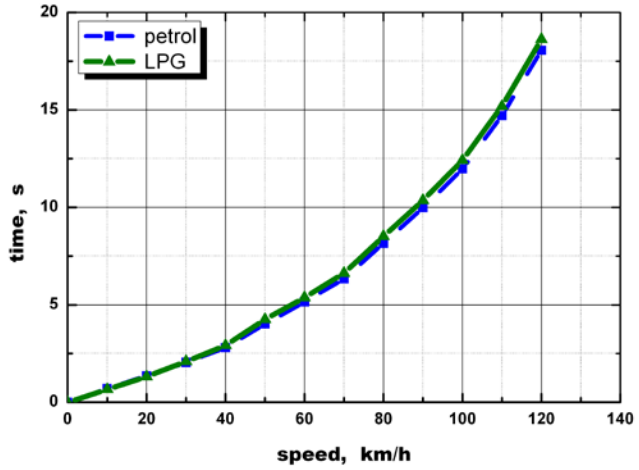

Fig. 7 *Florida In 1.6L- acceleration 0 - 120km/h*

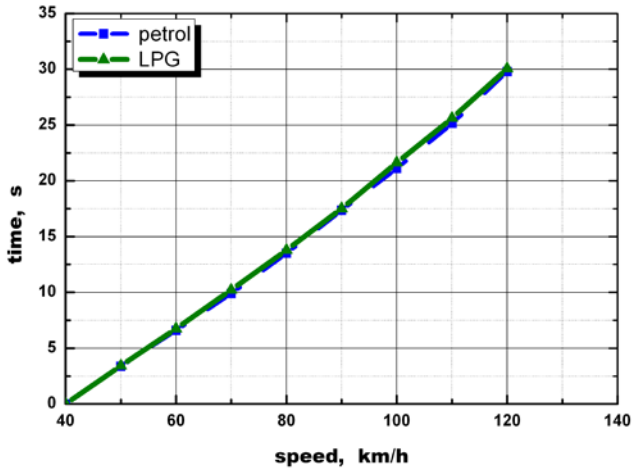

Fig. 8 *Florida In 1.6L- elasticity 40 – 120km/h*

Table 2: Fuel consumption- *vehicle Florida In 1.6L LPG*

	Fuel consumption (l/100km)	
	LPG	PETROL
urban	9.52(+12.4%)	8.47
combined	8.0(+10.5%)	7.24

Comparative measuring of consumption with petrol/LPG. In mixed test conditions, litre consumption with LPG was +10.5% higher, while in urban driving conditions litre consumption with gas was +12.4% was higher.

Fig. 4 and table 2 show the results of optimization on the vehicle Zastava Florida In 1.6 L TNG with OMEGAS Landi Renzo system for gas injection. Comparative results of measuring power on the wheel for petrol/LPG indicate insignificant decrease of power on the wheel in case of gas application, since the system was well adjusted, in high regime. The final aim of the performed adjustment was not obtainment of identical power for petrol and LPG, but optimization of power, consumption and emission with LPG. Major attention was given to economic effects of optimization, i.e. reduced consumption as a result of the adjustment.

Fig. 9 *Vehicle Punto Classic LPG*

As for adjustments on the vehicle FIAT Punto Classic LPG, where system for LPG was factory-installed, optimization was realized with the aim of achieving the same vehicle properties for driving with both petrol and LPG, which was ultimately accomplished according to the published data of the producer [8]. The principle of identical vehicle properties for both petrol and LPG is a feature of factory-installed adjustment for all producers.

Table 3: *Technical characteristics vehicle's FIAT Punto CLASSIC LPG 1.2[8]*

Engine	1.2 8v LPG	
total displacement, cm^3	1242	
compression ratio	9,8:1	
emission	Euro 4	
FUEL	LPG	PETROL
max. EEC power, kW/KS	44/60	44/60
rpm n_p, o/min	5000	5000
max. torque, Nm/kgm	102/10,4	102/10,4
rpm n_m, o/min	2500	2500
engine idle speed	900±50	

Table 4: *Performance[8]*

Performance	LPG	PETROL
top speed, km/h	155	155
acceleration 0-100km/h, s	14.3	-

Such method of adjustment has definitely influenced the increase of consumption in litres when driving with gas – for over 20%. Table 5 shows the comparative consumption values for vehicle with petrol/LPG. The effects of adjustment are in line with the recommendations of gas system producers. The obtained gas emission is more favourable, which was expected.

Table 5: *Fuel consumption according to Directive 2004/3/EC [4]*

	PETROL (l/100km)	LPG (l/100km)
urban	7.1	9.2 (+22.8%)
extra urban	4.8	6.0 (+20.0%)
combined	5.6	7.2 (+22.2%)
CO_2 emissions, g/km	133	116 (-12.8%)

4. Conclusion

Development and introduction of new solutions in car industry is a necessity, especially bearing in mind ever stricter market demands and valid regulations. In addition to that, it is necessary to improve the methods for estimation of performed interventions constantly. The presented results indicate the influence of installed sequential systems for LPG on vehicle properties, which is essential in vehicle development.

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