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LPG, A SOLUTION FOR OLD VEHICLES POLLUTION REDUCTION

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***Abstract*—** This paper present a study regarding the emissions produced by the old vehicle engines, and researches about the LPG as an alternative fuel for SIE. The engines utilizing LPG constitute an important part of ecological vehicle engine options. Experimental research has been done for one light vehicle, Dacia (year 2002) equipped with a 1397 (cm^3) Spark Ignition Engine with Power = 46 (kW) at 5500 (rpm) and Single Point Injection system. There were been made two tests, for each type of fuel (gasoline and LPG), for several increasing engine speeds, using a portable analyzer, GA-21 plus. The parameters measured with the analyzer and used in the analysis are: CO, CO_2, NO, NO_2 and SO_2. It was concluded that the highest pollutants values are when the vehicle was fueled with gasoline. In conclusion, Liquefied Petroleum Gas is the optimal solution in order to reduce the pollution produced by the old running vehicles.

***Keywords*—** LPG, Gasoline, Pollution, Spark Ignition Engine, Exhaust Gases.

I. INTRODUCTION

Vehicle pollutants are responsible for two third of air pollution in the urban areas. The major pollutants emitted by motor vehicles including CO, NO_x, sulphur oxides, (SO), HC and suspended particulate matter (SPM), have damaging effects on human health and environment ecology [1]. The human health effects of air pollution vary in the degree of severity, covering a range of minor effects to serious illness, as well as premature death in certain cases. Most of the conventional air pollutants are believed to directly affect the respiratory and cardio-vascular systems. In particular, high levels of SO2 and SPM are associated with increased mortality, morbidity and impaired pulmonary function. [2].

The Institution for Romanian Driving and Vehicle Registration presented the 2014 report showing that 54% of vehicles circulating in Romania are older than year 2002. In order to reduce pollution from old vehicles, an alternative is to use LPG.

Liquefied Petroleum Gas (LPG) is a mixture of gases, chiefly propane and butane, produced commercially from petroleum and stored under pressure to be kept in a liquid state [3]. The LPG is an attractive fuel for internal combustion engines; because it burns with little air pollution and little solid residue, besides that, it does not dilute lubricants, and it has a high octane rating [4].

Subject to space limitations, most combustion ignition engine vehicles can be converted to run on LPG. The common method for vehicles manufactured after year 2000 is the Single Point Injection system. Depending on the vehicle type, the LPG tank can be located crossways behind the rear seats, in the well beneath the boot floor where the spare wheel normally fits or in the boot space itself [5].

II. POLLUTION MEASUREMENT METHODOLOGY

The experimental researches has been done for a single vehicle, fueled with two different fuels: gasoline and LPG. The tested vehicle was a Dacia (year 2002) equipped with a 1397 (cm^3) Spark Ignition Engine with Power = 46 (kW) at 5500 (rpm) and Single Point Injection system.

There were been made two tests, for each type of fuel, from starting the engine operated at idle speed and for several increasing engine speeds: 1500 (rpm), 2000 (rpm), 2500 (rpm), 3000 (rpm), 3500 (rpm) and 4000 (rpm). In Figure 1 is presented the equipment and the placement of it in order to perform the measurements.

Fig. 1. Vehicle pollution measurements

The LPG and gasoline measurements ware made, using a portable analyzer, GA-21 plus as it shown in the

Fig. 2. The GA-21 plus is a multi-functional for different burning fuels gas analyzer. Electrochemical sensors are used for gas concentration measurements. The analyzer is fitted the next sensors: Oxygen O_2, Carbon monoxide CO, Nitric oxide NO, Sulphur dioxide SO_2, Carbon dioxide CO_2 and Nitrogen oxides NO_x [6].

Fig. 2. Madur portable analyzer, GA-21 plus

O_2, CO, NO, SO_2 are measured directly using the electrochemical cells. The remaining components are calculated. The concentrations of oxygen and carbon dioxide are shown in percent (%). The concentrations of the remaining gases is shown as follows: volume concentration in (ppm); absolute mass concentration in (mg/m^3); mass concentration relative to the oxygen content in (mg/m^3) [7], [8].

Also, the air inlet or ambient temperature and flue gas temperature are measured. Using the measured temperatures, gas concentrations and the known fuel parameters the analyzer calculates a variety of combustion parameters such as Stack Loss - SL, Efficiency - h, Excess Air - λ, Loss through Incomplete Combustion - IL [6].

III. POLLUTION RECORDERED DATA

There have been made two tests for the same vehicle, one with gasoline as fuel and second for LPG. The tests contains 7 reports for each fuel, and for the following engine speeds: idle speed - 920 (rpm), 1500 (rpm), 2000 (rpm), 2500 (rpm), 3000 (rpm), 3500 (rpm) and 4000 (rpm). The collected data are saved as database in order to analyze the results.

For every report following parameters are saved: parameters values (CO, NO, NO_2, SO_2, H_2S, H_2) measured by the equipment cells and expressed in (ppm); calculated parameters values (O_2 (%), CO_2 (%), NO_x (ppm)); calculated parameters values (CO, NO, NO_2, SO_2, H_2S, H_2) expressed in (mg/m^3); flue gas temperature, T_{gas} (ºC); ambient temperature T_{amb} (ºC); excess air factor λ [6].

IV. DATA ANALYSIS

The internal combustion engines performances depend on the quality of the combustion process that takes place inside the cylinders. Also, the combustion process depends on the perfection degree of the cylinder air intake and fuel injection systems [9]. By using the LPG as an alternative fuel for spark ignition engines, an ecological effect can be achieved by providing the engine with the proper adjustment (with the excess of air factor λ = 1) at all operating conditions. In order to achieve the optimal parameters, the operation of the engine needs to be verified on a test stand [10], [11].

The main pollutants variations depending engine speed are presented in Fig. 4, Fig. 5, Fig. 6, Fig. 7, Fig. 8 and Fig. 9. The variation of excess air factor λ is presented in Fig. 3.

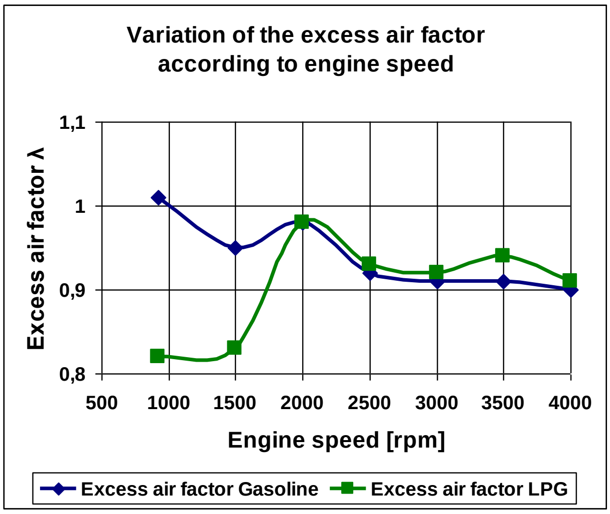

Fig. 3. Excess air factor λ variation in function of engine speed

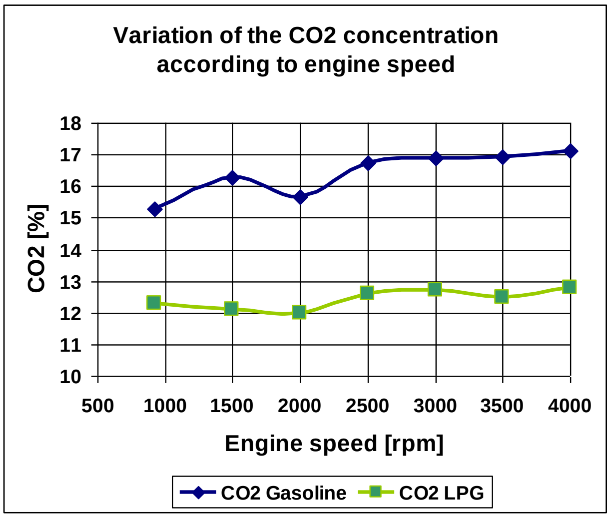

Fig. 4. CO_2 variation in function of engine speed

Complete combustion of LPG yields water vapor and carbon dioxide, which are, along with atmospheric nitrogen, the primary components of the exhaust gases of an gas engine. In real conditions, nitrogen oxides (NO_x), carbon monoxide (CO), sulfur oxides (SO_x), and various organic compounds are also produced [1].

The concentration of carbon dioxide is much lower in case of using LPG because the combustion is more complete. It can be noticed a lower CO_2 level in case of LPG test (12 -13 %) than with gasoline test (16 - 17 %).

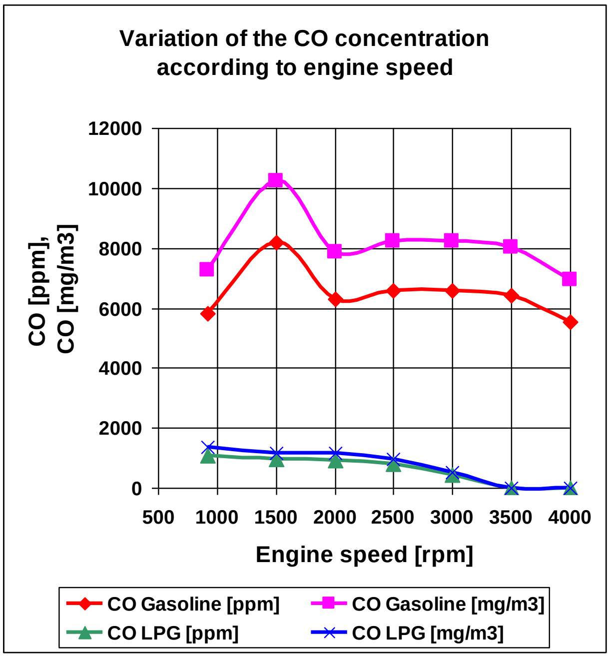

Fig. 5. CO variation in function of engine speed

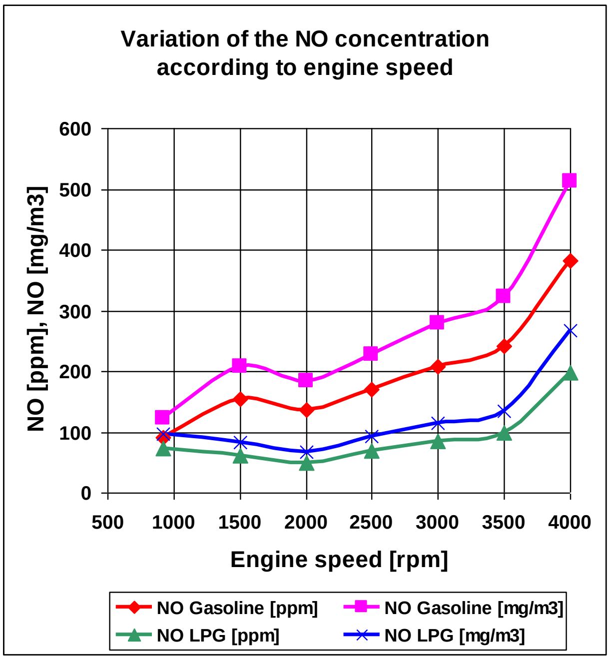

Fig. 6. NO variation in function of engine speed

The concentration of nitrogen oxides (NO_x) is the combination of nitric oxide (NO) concentration and nitrogen dioxide (NO_2) concentration. NO_x is formed from atmospheric nitrogen at high burning temperatures and pressures. The first part of oxidation produces NO, which is then oxidized by atmospheric oxygen or ozone and transformed into NO_2. The concentration of NO_x in the combustion gases are directly dependent on the combustion chamber design and engine operating parameters [1].

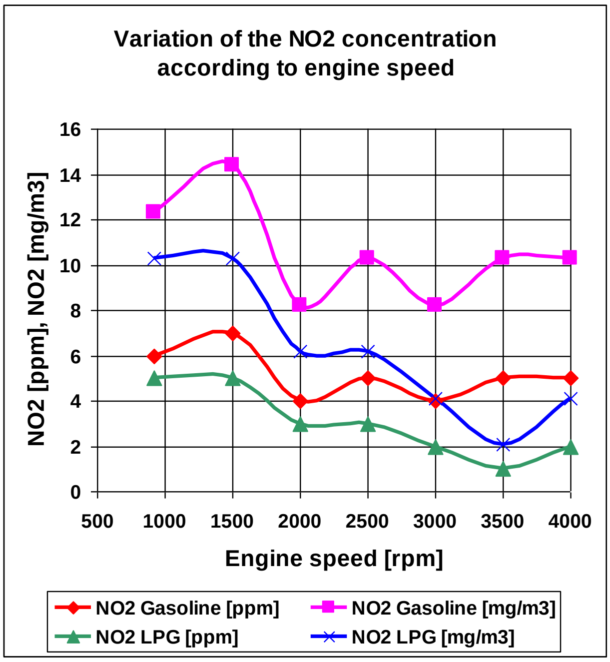

Fig. 7. NO_2 variation in function of engine speed

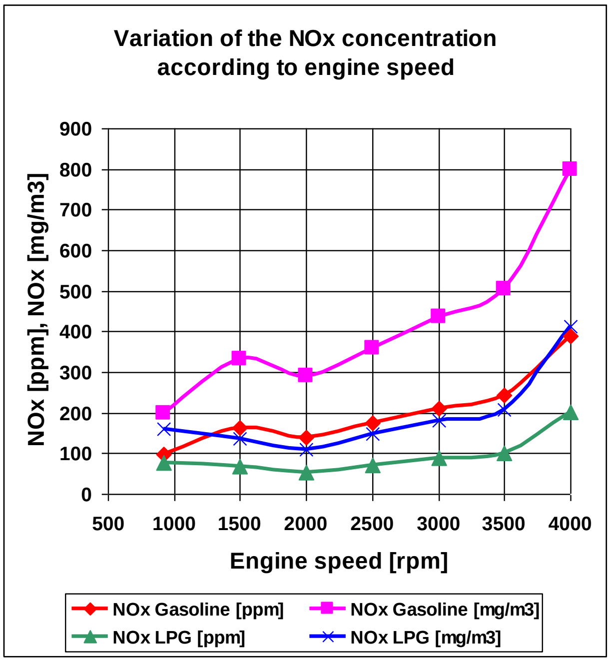

Fig. 8. NO_x variation in function of engine speed

It can be noticed a lower NO_x level in case of LPG test (~ 175 (mg/m^3) at idle speed and ~ 400 (mg/m^3) at 4000 rpm) than with gasoline test ((~ 200 (mg/m^3) at idle speed and ~ 800 (mg/m^3) at 4000 rpm).

The carbon monoxide (CO) concentration from the exhaust gases is related to the engine operating parameters, namely the amount of excess air utilized (λ), the uniformity of the air-fuel mixture, and the exhaust gases cooling system [1]. For LPG fueled engine test the level of carbon monoxide is much lower (< 2000 (mg/m^3) at idle speed and ~ 0 (mg/m^3) at 3500 and 4000 revolutions per minute).

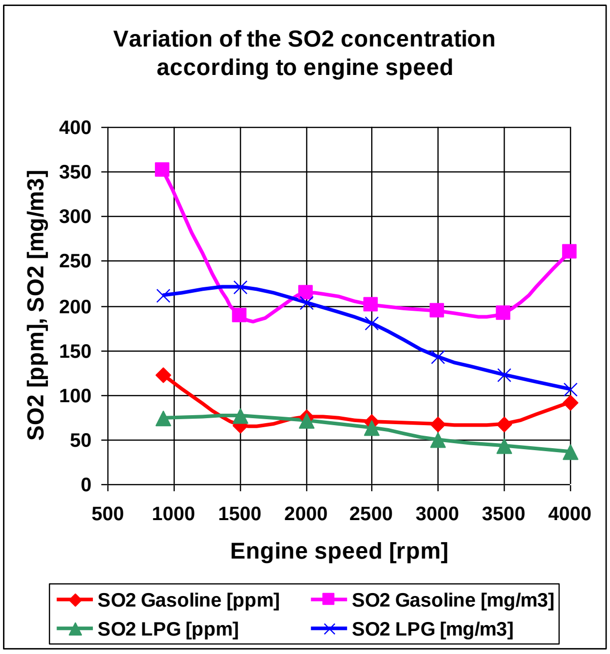

Fig. 9. SO_2 variation in function of engine speed

Presence of sulfur dioxide (SO_2) in the exhaust gases is caused by sulfur compounds in the liquefied hydrocarbon gases, as LPG [1].

In the case of sulfur dioxide, also the level is lower for LPG test (~ 200 (mg/m^3) at idle speed and ~ 100 (mg/m^3) at 4000 rpm) than with gasoline test ((~ 350 (mg/m^3) at idle speed and ~ 250 (mg/m^3) at 4000 rpm).

V. CONCLUSION

LPG was introduced to the automobile market as a clean-burning alternative fuel. His advantages are the following: low emissions of carbon monoxide compared to gasoline engines; no heavy unburn hydrocarbon emissions; low emission of benzene and 1,3-butadiene; lower cold-start emissions than gasoline [12].

In the present study was compared the exhaust gas emissions for one gasoline engine vehicle (2002 production date), fueled with gasoline and LPG. For all registered parameters, the values was much lower for LPG than gasoline. The values of CO, CO_2, NO, NO_2 and SO_2 was much lower in case of LPG tests (for engine operated at idle speed and for increasing engine speeds: 1500 (rpm), 2000 (rpm), 2500 (rpm), 3000 (rpm), 3500 (rpm) and 4000 (rpm)).

Because 54% of vehicles circulating in Romania are older than year 2002, in order to reduce air pollution, several reduction measures are needed [13]. For older vehicles, fuel consumption data can be used as an indicator of the level of vehicle pollutants. A vehicle using LPG, will have a higher fuel consumption (in liters/100 km) than the same vehicle using gasoline [14]. This is due to the difference in energy content between LPG and gasoline. When a liter of LPG is used by a combustion ignition engine vehicle, the level of CO_2 and pollutant emissions from the exhaust is lower than that for a liter of gasoline, because of the lower proportion of carbon in LPG relative to gasoline.

In conclusion, LPG is the most appropriate solution for exhaust pollution level diminish for older spark ignition engine vehicles (example: older than year 2002).

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