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Estimation of Environmental Efficiency for the Liquefied Gas Use as a Motor Fuel in the Internal Combustion Engine of Motor Vehicles

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ABSTRACT

Currently, the use of various types of alternative motor fuels, such as natural gas, methane (in liquefied or compressed form) and liquefied petroleum gas (LPG), has become more common in the world. In addition, various studies are carried out on the application of biological, synthetic fuels, dimethyl ether, etc. The widespread use of each of these fuels in internal combustion engines has both advantages and disadvantages, measured not only in terms of economic attractiveness, but also in terms of environmental safety. This article provides a method for estimating the environmental efficiency of liquefied gas as a motor fuel in vehicles.

Introduction

It is known that the operation of an internal combustion engine is accompanied by exhaust gas toxicity, in which about 1000 chemical compounds are found (Zvonov, 1981). The most dangerous ones, having a certain specific weight, are the carbon oxides (CO – 10 %), nitrogen oxides (NOx – 0.8 %), unburned hydrocarbons (UHCs – 3 %), aldehydes (0.2 %) and carbon black (Simonyan, Asatryan, 2013).

Taking into account the fact that the application of gas fuel in the car engines considerably reduces the amount of toxic compounds released into the atmosphere (Simonyan, 2011), the activities aimed at the solution of the mentioned problem become urgent due to the time demand.

Materials and methods

The chemical compounds discussed in the previous section have different effects on human organisms, since they have various toxicity degree and are characterized by different hazard levels. Besides, the mentioned compounds differ from each other by their quantity and volume in the exhaust gas of the car engine; that is why to provide clear distinction which compound is more dangerous for a specific car model is rather difficult (Korotkov, Filippov, 2008).

The total level of various toxic compounds in the exhaust gases is viewed as the hazard level in the car exhaust gases (Korotkov, Filippov, 2008).

From the environmental standpoint the gas fuels are serious competitors with the traditional oil fuels. The latter are based on the ratio of H/C (Abed Alib, et al., 2010).

Based on the aforementioned facts and the circumstance that the liquefied petroleum gas vehicles, particularly the light cars, have become widely used in Europe and CIS countries, which are mostly for personal use and passenger transportation companies (TAXI), it becomes necessary to study and assess the toxicity rate of the exhaust gas from the car engine depending on the car mileage (run).

Table 1. The technical description of Gas analyzer*

Chemical composition	**Range**	**Resolution**
HC	0 - 2000 ppm	1 ppm
CO	0 - 15 %	0.001 vol%
CO_2	0 - 20 %	0.01 vol%
O_2	0 - 25 %	0.01 vol%
NOx	0 - 5000 ppm	1 ppm
Working conditions		
Temperature	0-50 degree C	
Humidity	Up to 95 % non-condensing	
Altitude	- 300 to 2.500 m	
Vibration	1.5 G sinusoidal 5 - 1000 Hz	
Shock	1.22 m drop to concrete floor (gas analyzer)	
Response Time	0 - 90 % <= 8 seconds for NDIR measurements	
Pocket PC Power	5 VDC 2 Amps max	
Operating System	Windows Mobile/CE version 3.0 or later	

*Composed by the author.

Results and discussions

For our experiments new MERCEDES car model with a run of up to 5000 km and with E-class universal car body working with liquefied petroleum gas with 3.2 L swept-volume capacity has been selected, which is most applicable but not limited to passenger motor vehicles.

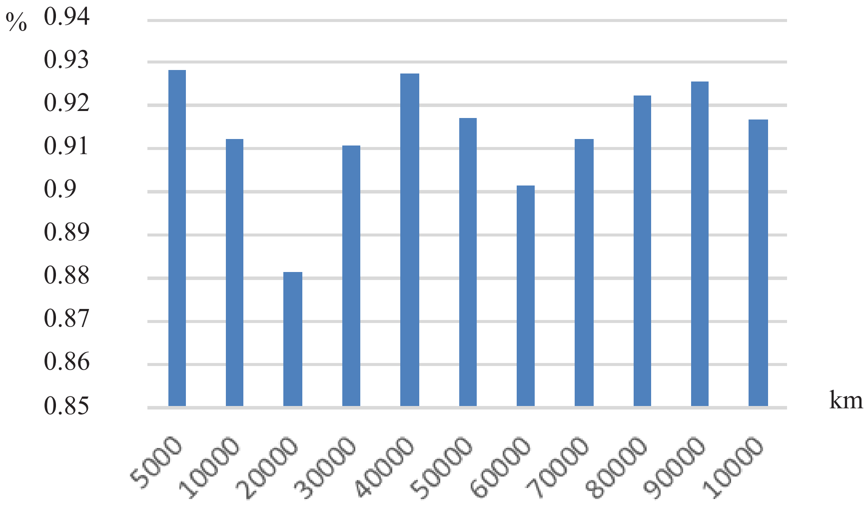
The estimation of both mass and volumetric toxicity of the exhaust gases from the MERCEDES cars has been conducted by means of GAS analyzer, the technical description of which (parameters) is introduced in Table 1, while the general view and operational state are presented in Figure 1 (a, b).

a) b)

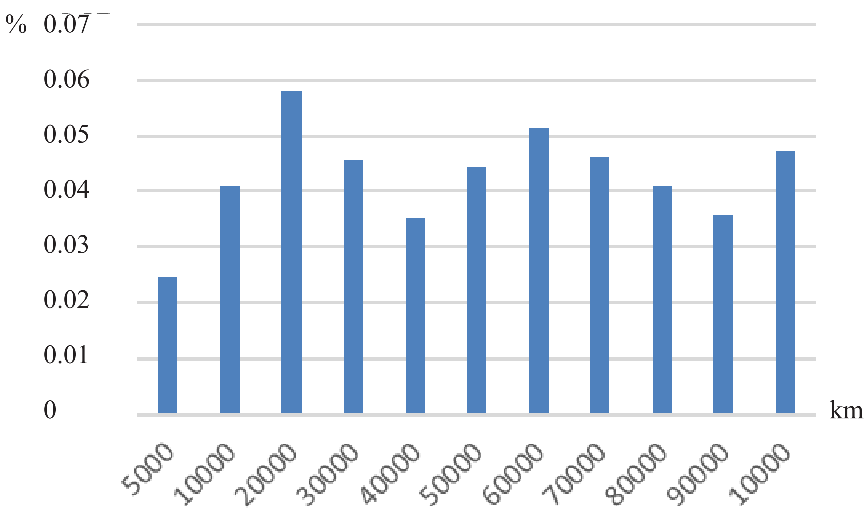
Figure 1. Estimation of the toxicity for the exhaust gases from the engine of MERCEDES-benz.

The experiments have been implemented in consistent with the standards of GOST 31967-2012, on the roads of the 1st category, at the constant vehicle speed, according to which after 5000-10000 km mileage run, at each 10000 km, the toxicity of the exhaust gases was determined, the average data of which are summed up in Table 2 and in Figure 2 (a, b, c).

a)



b)



c)

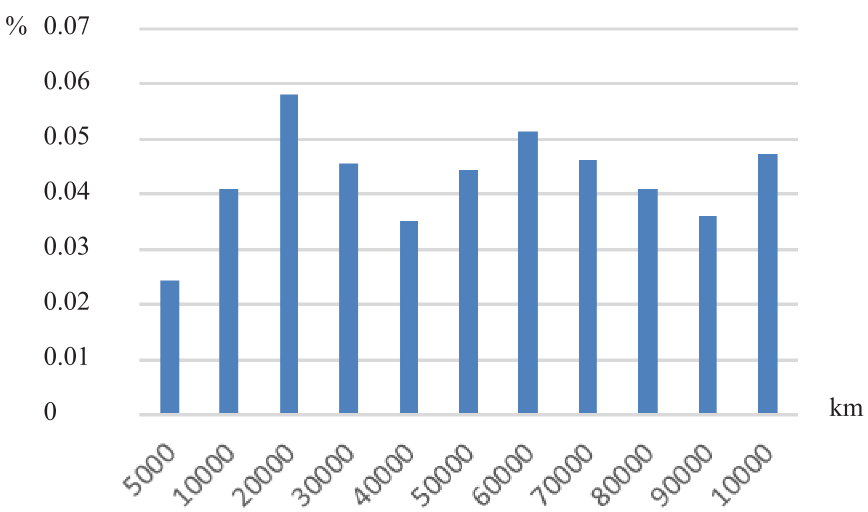


Figure 1. The amount of toxic compound emissions from MERCEDES-benz depending on its run.
a) The amount of CO b)The amount of UHC c) The amount of NOx (*composed by the author*).

Table 2. The amount of toxic compounds in the exhaust gases from the car model of MERCEDES-benz*

Run/Mileage, km	CO		HC		NOx		Σ	
	g/km	%	g/km	%	g/km	%	g/km	%
5000	4.54	0.928425	0.23	0.047035	0.12	0.02454	4.89	100
10000	4.68	0.912281	0.24	0.046784	0.21	0.040936	5.13	100
20000	3.95	0.881696	0.27	0.060268	0.26	0.058036	4.48	100
30000	4.6	0.910891	0.22	0.043564	0.23	0.045545	5.05	100
40000	4.75	0.927734	0.19	0.037109	0.18	0.035156	5.12	100
50000	4.55	0.917339	0.19	0.038306	0.22	0.044355	4.96	100
60000	4.22	0.901709	0.22	0.047009	0.24	0.051282	4.68	100
70000	3.95	0.91224	0.18	0.04157	0.2	0.046189	4.33	100
80000	4.05	0.922551	0.16	0.036446	0.18	0.041002	4.39	100
90000	4.12	0.925843	0.17	0.038202	0.16	0.035955	4.45	100
100000	4.07	0.916667	0.16	0.036036	0.21	0.047297	4.44	100

*Composed by the author.

The results of the research (Table 2), which have been carried out at the altitude of 80 m above sea level will enable to accomplish the following tasks:

1. to estimate the amounts of toxic emissions from the light motor vehicles (by the example of MERCEDES-benz), when working with liquefied petroleum gas,
2. to deduct a dependence characterizing the changes in toxic emission amounts from the engine due to the rate of vehicle run,
3. to compare and classify the toxic compounds in the exhaust gases,
4. to measure the amounts of toxic emissions and to compare them with the current standard values accepted in the Republic of Armenia,
5. to establish a comparative parametric database in case of obtaining similar results from new research conducted in the RA, which will be characteristic both to mountainous conditions (e.g. RA) and the areas close to sea level,
6. to compare the exhaust toxic gases from the engines of light motor vehicles working with compressed natural gas with equivalent compounds.

So, the data of Table 2 and Figure 2 indicate that the carbon oxide (CO) makes the overwhelming part of toxic emissions fluctuating within the range of 91 %-92 %, the unburned hydrocarbons (UHCs) are involved within the range of 3.6-6.0 in the domain of toxic emissions, and the share of nitrogen oxide(NOx) in the mentioned domain makes 2.4 %-5.8 %.

Conclusion

Upon the results of conducted research the following conclusions can be drawn:

Localization of the results of such scientific experiments or implementation of another research with the same content is urgent due to the abrupt increase in the number of motor vehicles running on liquefied petroleum gas in Armenia for recent years.

The carbon oxide (CO) is considered to be the most hazardous compound, which exceeds 90 % of the total amount of toxic compounds in the exhaust gases from the engine.

The ratio of nitrogen oxide (NOx) doesn't exceed 6 % of the total due to which we can view it as insignificant but not ignored.

The ratio of unburned hydrocarbons (UHCs) doesn't exceed 6 % either.

Parallel to the increase of the motor car run a maintaining tendency for the average values of toxic compounds in the exhaust gases of the engine is recorded.

References

1. Zvonov, V.A. (1981). Toxicity of Internal Combustion Engines, 2nd Ed., Revised, - M. :Machinery Construction, - 160 p.
2. Simonyan, A.R., Asatryan, G.S. (2013). Evaluation of Ecological Safety of the Motor Vehicle "Gaz-32213" Running on Compressed Natural Gas. Proceedings of the International Scientific Conference on the Problems of Agricultural Mechanization and Agricultural Engineering, NAUA.
3. Simonyan, A. (2011). Natural Gas as a Motor Fuel of the XXI Century. Scientific and Technical Conference with International Participation on the Subject: "Transport, Ecology-Sustainable Development": ECO VARNA.
4. Korotkov, M.B, Filippov, A.A. (2008). Assessment of the Environmental Efficiency for Using Various Types of Motor Fuel in the Internal Combustion Engine of Motor Vehicles. Alternative Fuel Vehicles - N1, January.
5. Abed Alib, A., Stanchevb, Kh., Kadikyanov, G., Simonyan, A. (2010). Comparative Studies of Gasoline Engines when Working with Gasoline and Liquefied Hydrocarbon Gas. Scientific Works of the University of Ruse, - V. 49, Series 4.
6. GOST 31967-2012. Reciprocating Internal Combustion Engines. Emissions of Harmful Substances with Exhaust Gases. Determination Norms and Methods (with Amendment No. 1).

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