EXHAUST GAS TESTS USING OF BIOFUELS IN IC ENGINES

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1. Introduction

Important action is to limit climate change and to reduce emissions from fuel utilization for the European Union (EU). In principle, there are many options to do, for example these priorities have been done by providing proportion of renewable energy in the fuel mix. The biofuels (biogas, vegetable oil, biodiesel, bioethanol etc.) are also parts of the renewable energy mix. Biofuel means liquid or gaseous fuel for engine use produced from biomass. Numerous studies demonstrate that the biofuels are environmentally sustainable and they have positive impacts on energy supply. The production of biofuels will help you find the balance in agriculture because biofuels can be generated from biomass, agricultural wastes and non-food plant material. In addition to the objective of saving emissions, EU biofuels policy aims to ensure the necessary energy and to decrease unemployment. So we would like to contribute to the EU requirements through our research. Such as exhaust gas tests using of biogas and different kinds of vegetable oils and biodiesel in internal combustion engines.

Keywords: biofuel, biogas, vegetable oil, internal combustion engine, exhaust gas, emission

2. The biogases as fuels and the emission

Emission tests were made on 24.6 kW power, 4 cylinder Wisconsin Motors Continental TM27 type gas engine with biogases. In our laboratory experiments the biogases were represented as mixtures of methane and carbon-dioxide and the tests were performed with these constant composition gas mixtures. Changing composition of biogas makes it difficult to test and would be uncertain general conclusion from test results.
Furthermore, the engine pre-ignition timing was stable because previous experiments indicated that operating range (function of air ratio) basically does not change due to the changing of pre-ignition timing, so the test engine can be operated stably. (Note: In case of various composition of biogas it is necessary to optimize the ignition timing.) So the constant conditions have allowed more reliable conclusions.
So we made engine tests under the following conditions: different air ratios ($\lambda \approx 0.8$-1.6), constant boost pressure (0.8 bar), constant compression ratio (1:11), specified pre-ignition timing (40°) and constant speed (1500 1/min). The air ratio factor is the most important parameter (gas engines usually operate at high access air – $\lambda \approx 1.2$-1.6) in terms of emission.

Mixed gases – with increasing carbon dioxide – fuelled engine cause increasing CO_2 in the exhaust gas (Figure 1). However, the increasing CO_2 emissions clearly due to the CO_2 content of biogases.

But there are many air pollutants from human activity and energy conversion, including nitrogen oxides (NO_x) and sulphur dioxide (SO_2). Those different compositions of biogases which have higher carbon dioxide content would have positive impact on NO_x emission in case of lean-burn operation, decrease can be 50%.
In case of $\lambda > 1.2$ air access ratios the cooling effect of the surplus air results lower NO_x emission, however, NO_x formation depends on the temperature. The engine operation with increasing carbon-dioxide content of gas mixture – by reason of drawing-off of combustion and cooling effect of carbon-dioxide – results further decreasing.

With increasing of carbon-dioxide rate of the applied biogas, the circumstances of the combustion are getting worse.

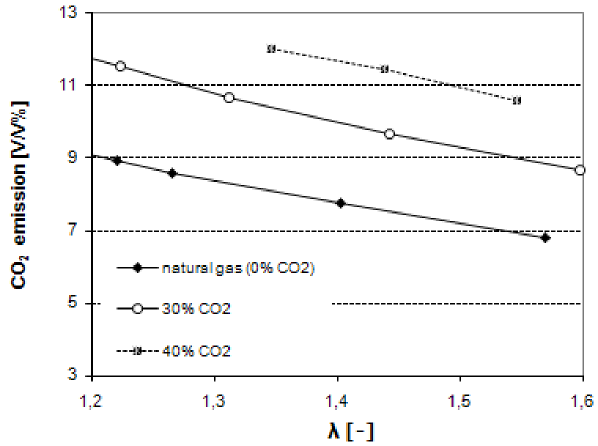

Figure 1 CO_2 emission of the gas engine

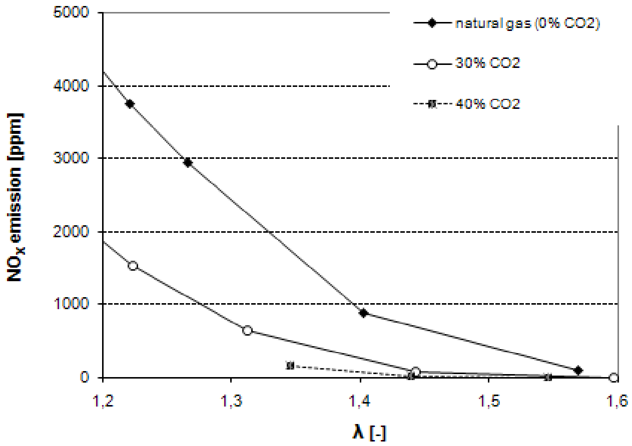

Figure 2 NO_x emission of the gas engine

The CO emission, however, in range of λ=1.2-1.4 air access ratios – independently of carbon-dioxide content of gas mixture – stabilized on lower values. In case of λ>1.4 air access ratios the dragging-on of combustion result increasing CO emission (and higher quantity of unburnt hydro-carbons). In terms of CO emission, unambiguously, it can be determined that the traditional gas engine is operated with gas mixture with low methane content, there is no effect on CO emission if the gas engine operates permanently in range of λ=1.2-14 air access ratios.

Furthermore, measuring of the methane content in the exhaust gas can give points of reference on the goodness of combustion process. Increasing the air absence and dragging-on of the combustion result similar tendencies considering the unburned hydrocarbons emission, too. It can be discovered that considering the incombustible hydrocarbon content of the exhausted gases there is no significant deviation present between the operation of natural gas and gas mixtures with a higher carbon-dioxide content in the range of λ=1.2-1.4 air access ratio.
The operation in the range of λ=1.2-1.6 air ratio gives lower emission in total.

Further studies are needed to compare systematically the environmental and energy performance of biofuels, taking a full lifecycle approach. We should create green house gas (GHG) balance in Hungary and in Europe.

3. The vegetable oils as fuels and the emission

In the frame of research supported by National Research and Development Programmes (NKFP) we determined engine brake bench results and emission components using of pressed 5 kinds of sunflower oils mixed with diesel oil, 4 kinds of rape oils mixed with diesel oil and RME. Our tests were performed by meeting requirements of the EU 24 and EU 49 standards with PERKINS 1104C C.I. engine type (Stage: EURO-2).

Table 1 ECE R49 Standard

Working point	RPM (1/min)	Loading (%) (Nm)	Weighty factor
1.	idle speed	0%	0.25/3
2.	$n_{M_{max}}$ 1400 1/min	10% 30 Nm	0.08
3.		25% 76 Nm	0.08
4.		50% 151 Nm	0.08
5.		75% 227 Nm	0.08
6.		100% 302 Nm	0.25
7.	idle speed	0%	0.25/3
8.	$n_{P_{max}}$ 2400 1/min	100% 302 Nm	0.10
9.		75% 227 Nm	0.02
10.		50% 151 Nm	0.02
11.		25% 76 Nm	0.02
12.		10% 30 Nm	0.02
13.	idle speed	0%	0.25/3

In the cause of our tests we put down CO, HC, NO_x, CO_2 and O_2 components of exhaust gases and determined smoking too. For defining concentrations of CO, NO_x, and CO_2 gas components a gas analysing computer working by spectrophotometer, type SERVOMEX XENTRA 4900 was used after adequate preparation of sample gas. A flame ionisation detector type RATFISCH RS 5 was used for defining CH emission.

After the emission tests it was stated that among the 5 kinds of sunflower oil mixed with diesel oil 4 fuels fell behind with 6.93 %-24.94 % from the CO value of diesel oil (Figure 3).

Among 4 kinds of rape oil mixed with diesel oil we noticed substantial falling (65% and 39.61 %) in two cases and rising (9.52 % and 4.56 % twice). The pure RME showed 26.42 % less CO emission the mixed fuel containing 10% RME decreased by 73.57%. CH emissions of all the vegetable oil-diesel oil mixed fuels remained under CH values of diesel oil (Figure 4).
To compare the values of mixed fuels with sunflower oils to diesel oil dropped by 18.6 % - 34.88 % and also slid by 26.16% - 66.28% using mixed fuels with rape oils. The pure RME represented 5.23% less CH values, the mixed fuel containing 10% RME dropped by 55.81%.

Among the 10 kinds of vegetable oil-diesel oil mixed fuels we measured higher NO_x values than diesel oil in only two cases of mixed fuels (Figure 5).

The samples with sunflower oils were slightly more favourable, than rape oil samples. Nine samples remained below the diesel fuel by 6.94% - 13.61%. Our further remark is that, the values of pure RME exceeded the NO_x limit of diesel oil with 6.54% and the mixed fuel containing 10% RME also exceeded by 10.72%.

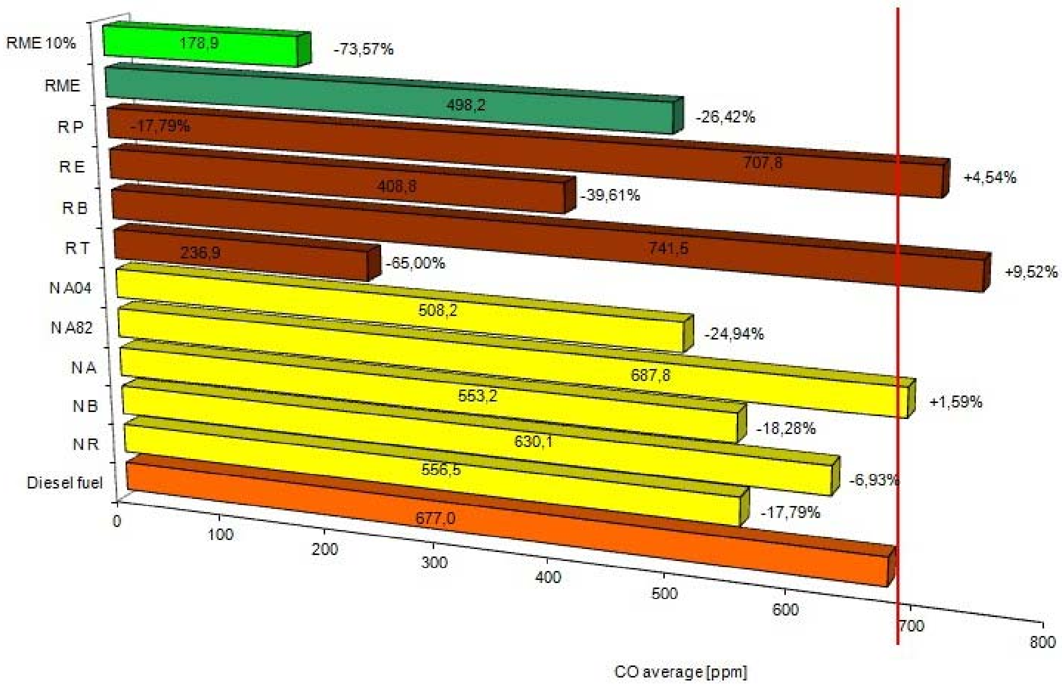

Figure 3 CO emission values

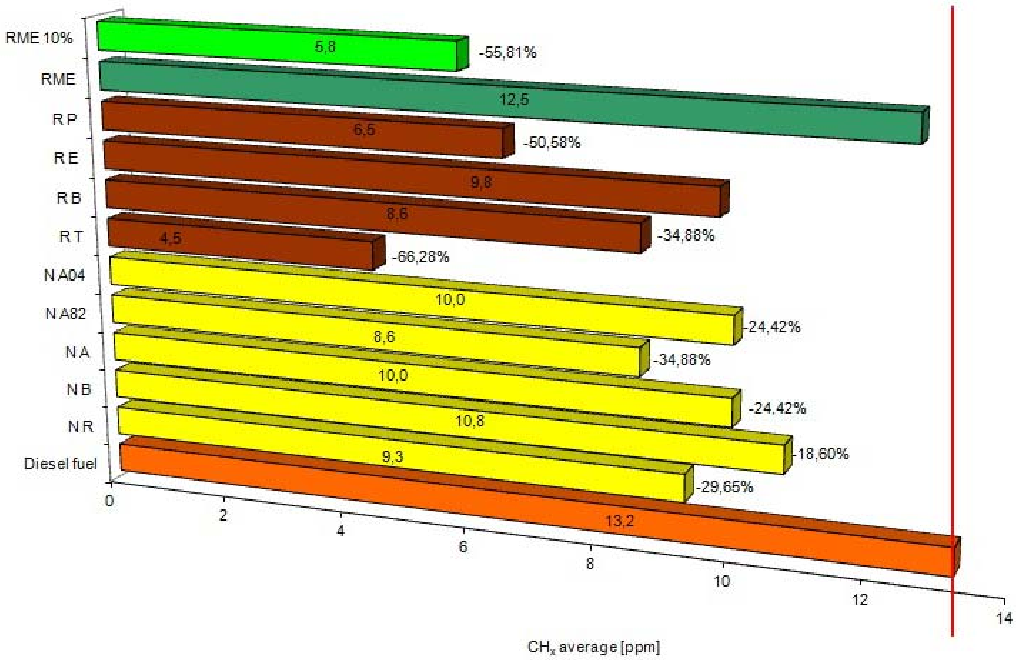

Figure 4 CH emission values

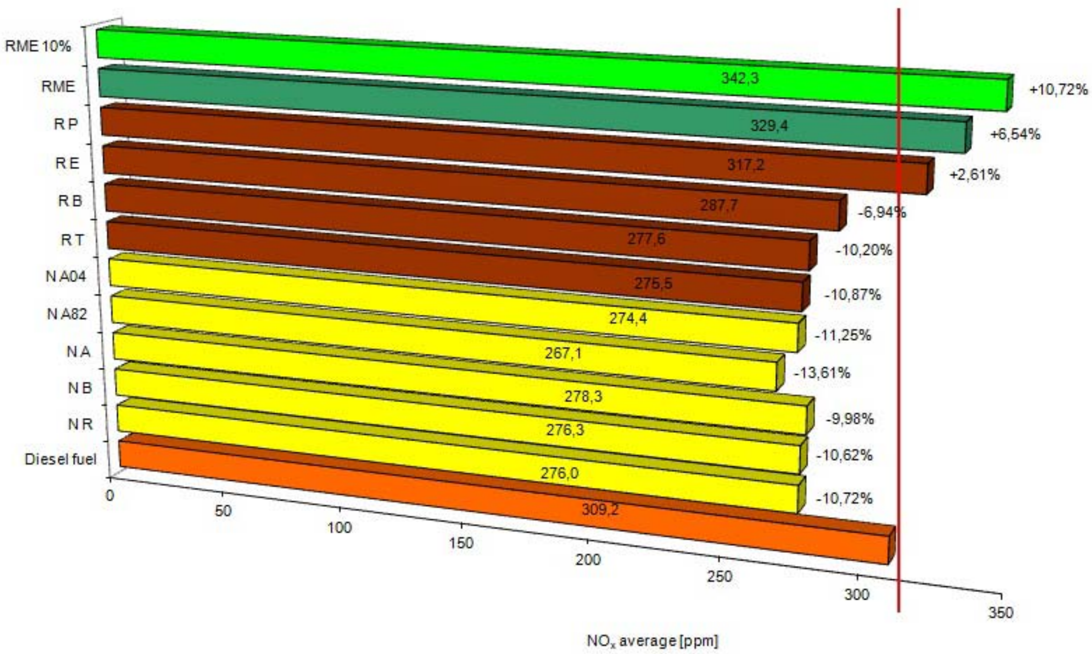

Figure 5 NO_x emission values

4. Conclusions, suggestions

It can be concluded that biogas and vegetable oils are applicable as fuel in internal combustion engines. The emission values of biofuelled engine are less than of fossil fuelled engine.

It can be determined that further researches are needed to compare systematically the environmental and energy performance of biofuels. Nowadays, it is being promoted besides the crop production (food production) to energy crops (biofuel production).

In summary, results of the research show that the biogas and different kinds of vegetable oils will have significant role in the future. And renewable energy carrier can be promoted by continuous innovative activities.

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