DIFFERENT FUEL TYPES AND THEIR EXHAUST GAS EMISSIONS

RÔZNE TYPY PALÍV A EMISIE ICH VÝFUKOVÝCH PLYNOV

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Abstract

The reduction of natural resources of fossil origin, significant environmental pollution and political instability of most oil exporters contributed to the necessity of finding solutions for their substitution with some other alternative fuels. There is a number of undesirable substances which could be found in the products of SUS engine combustion: carbon monoxide, Nitric Oxides (NOx), uncombusted carbon hydrogens CH, coke particles (soot, black smoke), fragrant substances, lead, sulphur compounds. With the aim of identifying the influence of different fuel types on the change of exhaust gas emissions, there were investigations of standard fuels of fossil origin (D-2 and Euro Diesel), biodiesel and their mixtures (D-2 fuel containing 50 and 20% of biodiesel, Euro Diesel containing 50 and 20% of biodiesel) that were carried out at the Faculty of Agriculture in Novi Sad, Department for Agricultural Engineering. The investigations were conducted at different revolutions (r.p.m.) and different engine loads.

Keywords: fuel, exhaust gas, emissions

INTRODUCTION

For many years, liquid fossil fuels have been primary and most dominant fuels for drive mobile machines. The development of mobile machines was predominantly based on the use of these fuels, so any expectations about stopping this trend of development in the following period would be unreasonable.

However, the reduction of available resources of oil that is fossil in origin, a significant environmental pollution caused by excessive exploitation of oil products (causing greenhouse effect), as well as political instability of most major oil exporters, led to the necessity of finding solutions for their substitution with some other alternative fuels.

Oil and its derivatives are extremely phytotoxic, so the pollution caused by these organic liquids could induce considerable damage to the nature, which is directly reflected on the production of safe food**.**

Biomass is probably the oldest energy source which can be used in its unchanged state, but also in its gas or liquid state, after technological processing._Biodiesel, bioethanol and biogas are ideal substitutes for oil derivatives, and they require only small or even no alterations of the existing engines.Use of these fuels directly influences the reduction of CO_2 emissions from transport fuel combustion, which will have reached 1.113 millions of tons by the year 2010. The ’’Kyoto Protocol’’, so far ratified by 120 countries in the world, predicts the necessity of providing conditions for the preservation of the environment (by the year 2010, level of the emitted CO_2 should be reduced to the level that was present in 1990) which would lessen the greenhouse effect that results in global warming of the atmosphere. In that regard, the European Union regulations obligate its members to secure an increase of the bio fuel level in transport fuels, which was 2% in 2005, and should be at least 5,75% in 2010. Biodiesel is an energy-generating product composed of fatty acid methyl esters of plant or animal_origin._Brkić (2005) stated that during the production and processing of rapeseed oil for gaining 1kg of

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biodiesel, total emission of gases relevant to climatic conditions is 1,42kg. The amount of the same gases, during the production of 1kg of diesel of fossil origin, is 4,4kg. Therefore, the production of biodiesel fuel could be regarded as ecologically clean technology.

MATERIAL AND METHOD

Investigation of the exhaust gas emissions was carried out by simultaneous observation of tractors running on biodiesel, standard fossil fuel (D-2 and Eurodiesel), and their mixtures, obtained by blending 20 and 50% of biodiesel into standard fuels. Investigation of quality of the used fuels was performed by reference Laboratories: ‘Jugoinspekt Novi Sad‘ (D-2 and Eurodiesel), Laboratory for Soil and Agroecology at the Institute of Field and Vegetable Crops, Novi Sad (Biodiesel), and SP Laboratorija AD, Bečej (Biodiesel). The results of the investigated fuels showed that biodiesel quality was in accordance with EN 14214 standard, and D-2 and Eurodiesel quality with SRPS EN 590 standard.
The investigation was carried out on MTZ 1025 tractor, (Figure 1).
The investigated MTZ 1025 tractor had four-cylinder engine D-245 with engine number 161365. The Number of working hours before the investigation was 1520 mh, and registration number was KI 6356.

Figure 1. The investigated MTZ 1025 tractor

Nominal engine power is 77 kW (105 HP), at 2200 rpm. Engine volume is 4750 cm³. The maximum_torque is 375 Nm, while reserve torque is 20%.
Investigation of the exhaust gas emission was performed at different numbers of revolutions and specified operating regime of engine (engine load). The investigation was performed by gas analyzer produced by TRC, Novi Sad (Figure 2).

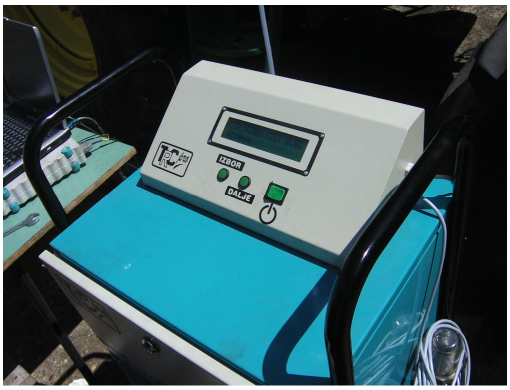

Figure 2. Gas analyzer produced by TRC, Novi Sad

The following parameters were included in the investigation:

- Content of coke particles (smokiness – opacity)
- Content of carbon monoxide
- Content of carbon dioxide

RESULTS AND DISCUSIONS

The products of SUS engine combustion contain various undesirable ingredients: carbon monoxide CO, nitric oxides NOx, non-combusted carbon hydrogens CH, coke particles (soot, black smoke),fragrant substances, lead, sulfur compounds.

Depending on the engine type, operating regime and regulations, 1 ton of fuel combusted in an engine can produce exhaust gases containing 150-180 kg of CO, 7.5-40 kg of NOx and 30-100 kg of CH. Torović (1993) presented similar data, indicating that during the combustion of 1kg of diesel fuel (fossil in origin) releases 80-100g of toxic matter (CO=20-30 g, NOx= 20-40 g, CmHn=4-10 g, SOx=10-30 g, soot 3-5 g, and aldehydes 0.8-1.0 g).

In soil pores, oil derivatives and products of SUS engine combustion can be present in an independent liquid phase, or in the form of vapour. They can also be attached to soil particles, dissolved in the soil solution or underground waters, or they can be present in the form of floating drops. All the above mentioned compounds in the soil, cause reduction of biological activity, disorder in the number of different microorganisms, heavy metal pollution, salinity increase, alkalization and acidification, which all have consequences for the food safety.

In the case of incomplete carbon combustion in the fuel, due to lack of oxygen in the combustion chamber, carbon monoxide occurs in the combustion products. The richer the mixture, the higher CO content in the combustion products. CO is a gas without colour or scent. Instead of oxygen, it gets attached to red blood cells in the lungs, thus reducing the oxygen level in an organism, and therefore, is extremely dangerous. According to its toxicity, carbon monoxide could be placed somewhere in the middle of the scale. Allowed maximum content of this compound is 50mg/m³ in the work environment, and 4.4 mg/m³ in the living environment.

The diagram shows variations in carbon monoxide content in the combustion products of MTZ 1025 tractor, at different numbers of engine revolutions and during the combustion of different fuel types (Figure 3). It can be observed from the diagram that at maximum number of engine revolutions 2250 r.p.m. the content of carbon monoxide is 0,03% during biodiesel combustion, which is 33% less than the content of carbon monoxide emitted during the fossil fuel combustion (D-2 and Eurodiesel).

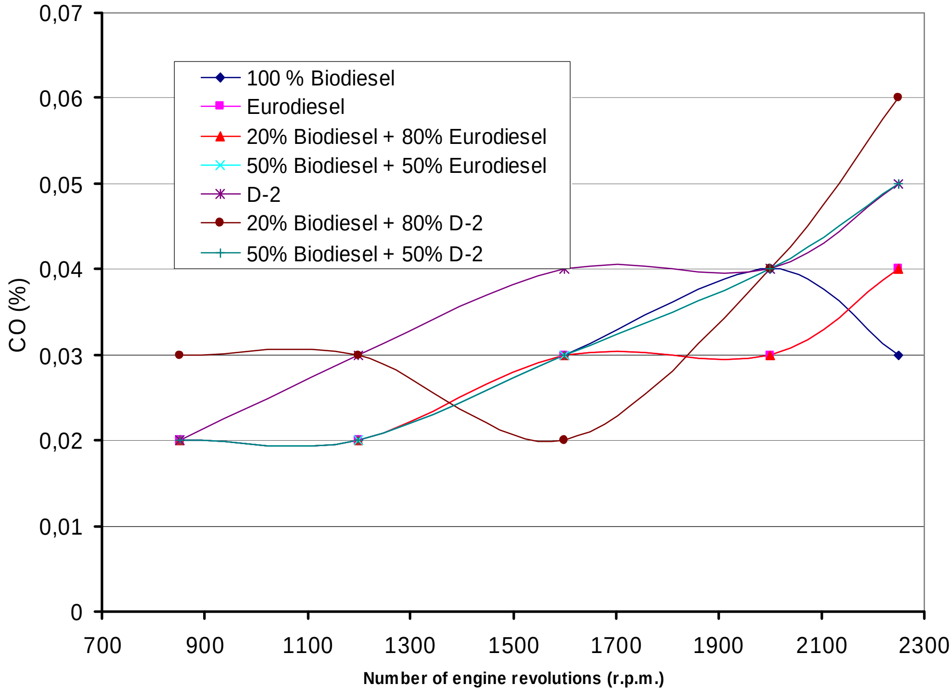

Figure 3. The content of carbon monoxide in the combustion products of MTZ 1025 tractor during the combustion of different fuel types (%)

It is said that biodiesel closes the circle of CO_2 emission and consumption, since practically all the amount of CO_2 emitted into the atmosphere during biodiesel combustion is later spent on the growth and development of plants which are used for biodiesel production.

This secures the reduction of greenhouse effect. Namely, the combustion of 1 ton of fossil diesel emits around 2,8 tons of CO_2 into the atmosphere. The combustion of the same amount of biodiesel fuel emits 2,4 tons of CO_2 into the atmosphere (Mitrović, 2006). Comparative researches of the content of exhaust gases from the engines using biodiesel and those using fossil diesel fuel, showed no significant difference in the CO_2 emission (Brkić 1995, Riva 1994, Tešić 1994, Tica 2006).

Diagram shows variations in the emitted carbon dioxide combusted by different fuel types in MTZ 1025 tractor and at different numbers of engine revolutions (Figure 4). It can be seen from the diagram that there is no significant difference in the emitted content of carbon monoxide combusted by different fuel types.

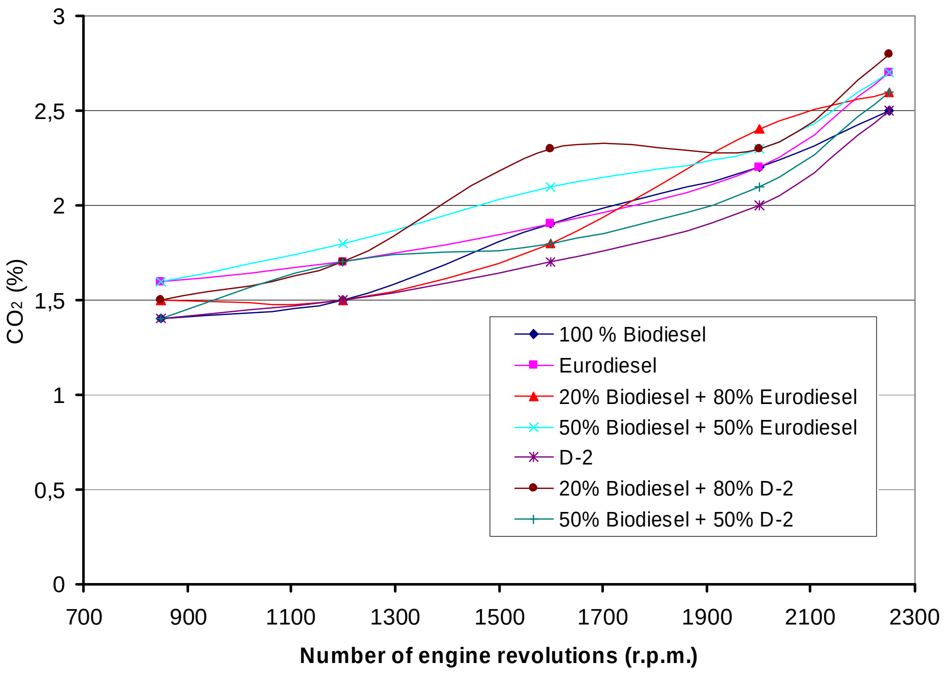

Figure 4. Content of carbon dioxide in the combustion products of MTZ 1025 tractor, during the combustion of different fuel types (%)

Of all the aspects of diesel engine toxic emission, smoke is the most obvious one, considering the fact that its presence is immediately detected. Smoke particles basically represent carbon in the form of soot, which is attached to different organic and non-organic compounds developed during the process of combustion. These compounds give particles toxic features. The size of smoke particles ranges from 0,1 to 300 μm, but most of them are smaller than 1μm. Black smoke is comprised of extremely tiny particles that are smaller than 1μm in size and have the ability to change the optical properties of exhaust gases. The methodology of the black smoke measurement is based on this ability. The operating principle of opacimeter is based on sending the light beam through the gas that is being measured, and measuring the amount of light that reaches a particular receiver.

Standard opacimeters measure the absorption coefficient K (m^{-1}). In our country, the allowed limits for values of absorption coefficient are K=3.22 m^{-1} for vehicles of up to 73,5 kW, and K=2,44 m^{-1} for vehicles over 73.5 kW. The diagram shows changes of the absorption coefficient for different fuel types, depending on the number of engine revolutions (Figure 5). It can be observed that in the range of 1600 rpm, the amount of the emitted soot particles in combustion products is equable. With the increase of number of engine revolutions, the amount

of the emitted soot particles is approximately 61% lower during biodiesel combustion than during fossil fuel combustion.
Low contents of soot particles and carbon monoxide emitted during biodiesel combustion signify more complete combustion than it is the case with fossil fuels.

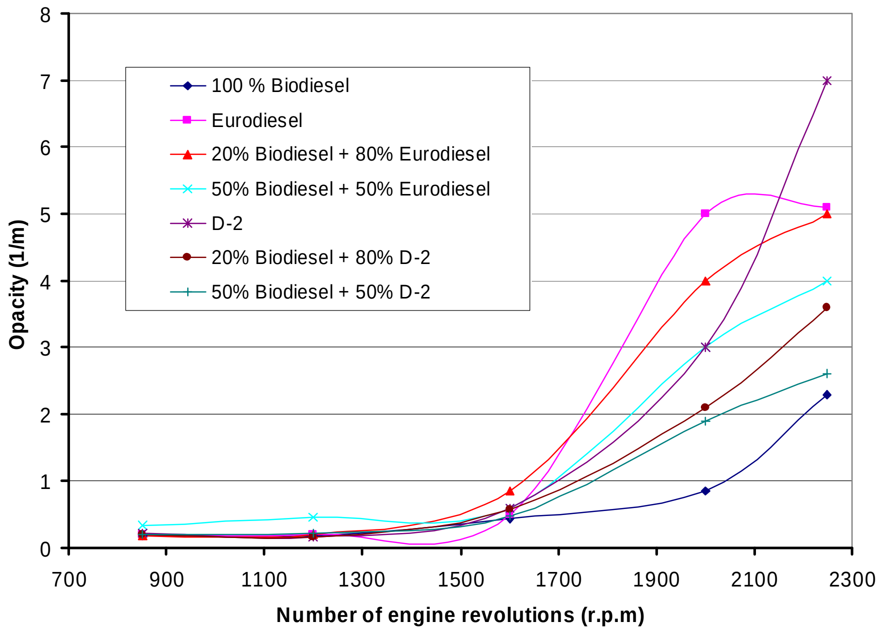

Figure 5. Exhaust gases opacity for some fuel types, at different numbers of engine revolutions

Analyzing carbon monoxide content in combustion products, under engine load higher than 30kW, it was concluded that biodiesel combustion releases 53 and 10% less gas than D-2 and eurodiesel respectively. All the investigated fuel types had carbon dioxide content that was in range of 4 -4.7%. The smokiness measured for biodiesel was 10% lower in comparison to D-2 fuel, and 16% in comparison to eurodiesel.

CONCLUSIONS

On the basis of the conducted researches of the exhaust gas emissions, the following conclusions could be drawn:

- In the engine combustion products, carbon monoxide emission is on average 23% lower in comparison to fossil fuels
- Level of carbon dioxide emission was equal during both biodiesel and fossil fuel combustion
- In comparison to fossil fuels, soot particles emission was on average 65% lower during the biodiesel combustion.

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Kľúčové slová: palivo, výfukový plyn, emisie.